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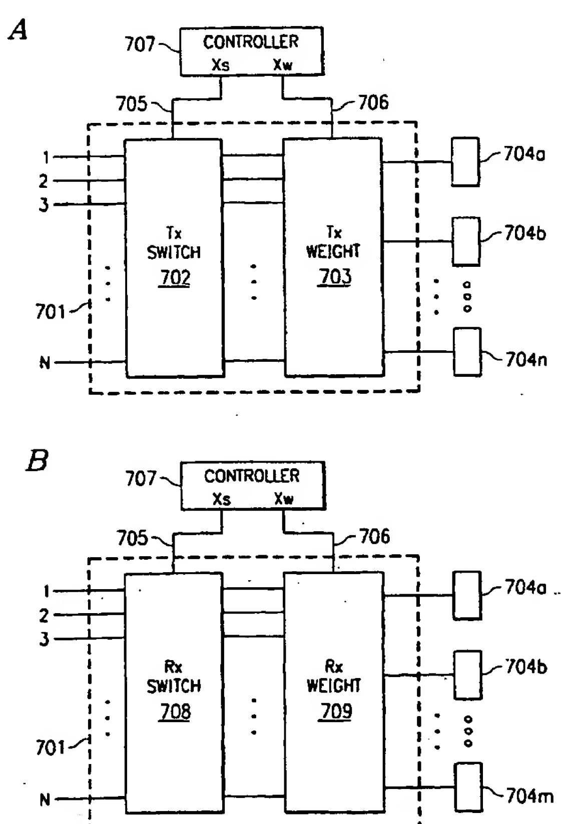


(57) Abstract: A system and method are disclosed for dynamically sizing sectors of a multi-sectored radiation pattern. The disclosed invention teaches the use of multiple narrow beams composited to form a radiation pattern. Signals associated with each such narrow beam may be provided to inputs of a scan receiver or signaling radio which inputs are associated with a particular sector of the radiation pattern. The number of narrow beam signals provided inputs associated with a particular sector defines the azimuthal width of the sector. By altering the number of narrow beam signals provided each such input, the azimuthal width of the sectors may be adjusted. The disclosed invention also teaches the use of attenuators in the signal path between the narrow beams and the scan receiver or signaling radio. By adjusting these attenuators, the effective length of the sectors may be adjusted. Alternatively, adaptive arrays may be utilized to form radiation patterns, for which the azimuthal width and length of a sector may be adjusted by way of adjustments of the relative amplitude and phase of signals at antennas of a phased array adaptively controlled according to communication parameters such as information indicating the quality of the communication channel on that sector or the number of calls serviced in particular sectors.

WO 01/15477 A1

ANTENNA DEPLOYMENT SECTOR CELL SHAPING SYSTEM AND METHOD

RELATED APPLICATIONS

The present application is a continuation-in-part of co-pending, commonly assigned, U.S. Patent Application, Serial No.08/924,285, entitled “ANTENNA DEPLOYMENT SECTOR CELL SHAPING SYSTEM", filed September 5, 1997, which is a continuation-in-part of co-pending, commonly assigned, U.S. Patent Application, Serial No. 08/786,725, now issued as U.S. Patent No. 5,889,494, entitled "ANTENNA DEPLOYMENT SECTOR CELL SHAPING SYSTEM AND METHOD", filed January 27, 1997, which applications are hereby incorporated by reference. Reference is also hereby made to U.S. Patent Application, Serial No. 09/280,307 entitled "SYSTEM AND METHOD FOR IMPROVED TRUNKING EFFICIENCY THROUGH SECTOR OVERLAP”, the disclosure of which is incorporated herein by reference. Reference is also hereby made to the following co-pending and commonly assigned U.S. Patent applications: APPARATUS, SYSTEMS AND METHODS FOR MULTIPLE ANTENNA TRANSMISSION IN WIRELESS COMMUNICATIONS SYSTEMS, Serial No. 08/520,316, now issued as U.S. Patent No. 5,648,968; METHOD AND APPARATUS FOR IMPROVED CONTROL OVER CELLULAR SYSTEMS, Serial No. 08/582,525, now issued as U.S. Patent No. 5,884,147; and SYSTEM AND METHOD FOR CELLULAR BEAM SPECTRUM MANAGEMENT, Serial No. 08/651,981, now issued as U.S. Patent No. 5,745,841; the disclosures of which are hereby incorporated herein by reference..

TECHNICAL FIELD

This invention relates to cellular antennas and more particularly to a system and method for providing flexible sector shaping within a multiple sector cell, including both the ability to adjust the sector's length, as referenced in the direction of propagation of the radiation, as well as its width, as referenced azimuthally.

BACKGROUND

As cellular communications become more widely used, the number of individual users and calls multiplies. Increase in cellular communications utilization magnifies the opportunity for interference between the different users on the cellular system. Such interference is inevitable because of the large number of users and the finite number of cellular communications cells and CDMA code channels which are available.

This invention applies to Code Division Multiple Access (CDMA) system, where the users would be separated from one another, either using different codes and/or different time delays of the same code, while utilizing the same frequency band. Because of this use of the same frequency band, there is a potential, as the system becomes loaded with a large number of users, of heavy traffic interference between one user and another limiting the capacity of the system. The comparable system for analog would have users separated on different frequencies with reuse of the same frequencies provided for with a guard distance or guard zone (reuse distance) between points in which the same frequencies are used again. There are certain problems that are inherent to CDMA networks including interference from one cell to another, since typically every cell reuses the same frequency. The forward link at any particular mobile's location may receive interference from a number of cells. Some of those would be desired cells that the mobile would be in handoff with. Others would be cells that the mobile could not be in handoff with, but that would interfere with the signal that the mobile was receiving. An analogous problem happens on the reverse link, where a cell site would receive signals from a number of mobiles; the desired mobiles that are within the coverage area of that sector, as well as mobiles that are being served by other cells, that interference would limit the capacity of a given sector.

To reduce the interference problems caused by other users in the omni cell 360° configuration, cells have been broken down into 120° sectors such that each channel available at the cell only communicates in an area of 120° radial coverage about the cell. An advantage, in addition to the reduction of interference realized by the sector system, is that such a cell achieves extended range as compared to an omni cell 360° system simply due to the ability to focus a greater signal gain on the antennas. Individual cells may then cover a larger area, and communications signals may be stronger within the cell.

It shall be appreciated that loading of sectors is often cyclic or dynamic in nature rather than constant. For example, during certain times of day, such as business commuting times, a

particular sector, such as a sector encompassing an urban highway, may service more users than during other times of day. Therefore, during particular times a particular sector or sectors may require increased capacity in order to service all users whereas at other times the cell's capacity might be better utilized when spread more homogeneously throughout the cell's coverage area.

It would, therefore, be advantageous to make more efficient use of cellular capacity by being able to make sectors dynamically shapable in order to provide increased capacity to a particular area within the cell's radiation pattern by making more channels potentially available to that particular area. Ideally, the shapable sectors will be composed of narrow beams so as to provide a convenient means by which sectors may be sized radially about the cell. Systems implementing such narrow beams are described in U. S. Patent Number 5,563,610, entitled "NARROW BEAM ANTENNA SYSTEM WITH ANGULAR DIVERSITY," incorporated herein by reference, and the associated above-referenced co-pending and commonly assigned continuation-in-part U. S. Patent application entitled "APPARATUS, SYSTEMS AND METHODS FOR MULTIPLE ANTENNA TRANSMISSION IN WIRELESS COMMUNICATIONS SYSTEMS." Management of such a system, including concurrent beam and channel management within a neighborhood of cells, is disclosed in the above referenced co-pending and commonly assigned U. S. Patent application entitled "METHOD AND APPARATUS FOR IMPROVED CONTROL OVER CELLULAR SYSTEMS."

Another problem in the art is that in a cellular system, communications are typically mobile, often in vehicles traveling at considerable speed. Such mobile communication devices tend to travel through the various sectors and/or cells of a cellular system, thereby continuously effecting signal quality as fringe or shadow areas are entered and exited. These effects of signal quality are not limited to the mobile communication device itself, but also effect other communication devices operating in the area. For example, a communication device operating in one cell, although experiencing acceptable signal quality itself, may in fact be causing interference for another communication device. Such interference may be in the form of frequency reuse interference, near/far problems, increased energy density and the like. Therefore, it is desirable to provide a means by which such a communication device may be handed off to another sector or cell, although its communication parameters do not necessitate the handoff, in order to better serve another communication device. Likewise, such a communication device may be experiencing communication of a quality so as to be within

acceptable parameters although communication of a better quality may be had through an adjacent sector or cell.

One benefit or use of this changing of the sector size would be to load balance the traffic among the sectors of a cell or sectors of adjacent cells. A particular example would be a case where one sector was at a capacity limit, such as either running out of transmit power or being unable to support any additional users. Other sectors on that cell may have additional capacity to spare, by rotating the orientation of the sectors and/or changing sector widths such as by mapping sectors to beams in a more optimum way, could equalize the load across the sectors and alleviate the overload condition on the sector that previously had reached a capacity limit.

Recognizing the mobility of communications and the attendant communication quality issues, therefore, it would also be advantageous to be able to dynamically shape sectors in their longitudinal, or outboard, reach from a cell site. Preferably, as it is determined that a communication device is causing interference for another communication device or as it is determined that this communication device may itself be better served by another sector or cell, the shape of the sector currently serving the communication device may be adjusted to force a handoff of the communication device to another sector or cell. Likewise, where capacity remains in a sector of any adjacent cell, the sector at capacity could reduce its area of influence simultaneously with the adjacent sector increasing its area of influence, in order to provide additional capacity within the area originally serviced by the sector that previously had reached a capacity limit. Ideally, the longitudinal shape of sectors will be accomplished through the use of attenuators in the receive signal path and equivalent gain adjustments of transmit power in the transmit path.

A need therefore exists in the art for a system and method for dynamically adjusting the shape of cell sectors to provide for greater trunking efficiency and the ability to serve more users. Moreover, a need in the art exists for such a system to provide azimuthal as well as longitudinal shaping of the sectors.

SUMMARY OF THE INVENTION

In a preferred embodiment, the present invention uses a multiple narrow beam antenna system to provide dynamically shapable sectors within a cell. By dynamically shaping the various sectors of a cell, problems of interference, such as frequency reuse interference or interference due to decreased carrier to noise ratio and the like, as well as channel depletion within a sector that attend the 3-sector system in wide use today may be addressed. Furthermore, through the use of dynamic sector shaping, the present invention provides the technical advantage of both increasing the number of users in a particular area which may be serviced by a cell as well as decreasing the interference to other cells.

Although any number of beams may be used in accordance with the principles of the present invention, a preferred embodiment uses 12 such beams. In order to provide 360° coverage radially about the antenna system utilizing 12 beams, each beam is adapted to provide approximately 30° azimuthal coverage.

Dynamic assignment of beams to a particular sector within the cell results in the ability to adjust the sector's width, as referenced azimuthally. For example, assigning 2 of the aforementioned 30° beams to a sector provides a sector having a 60° radiation pattern. Likewise, assigning 6 of the aforementioned 30° beams to a sector provides a sector having a 180° radiation pattern.

By dynamically shaping sectors, the invention may expand and/or contract certain sectors during certain times of the day as utilization demands. Accordingly, in a CDMA system, energy associated with a particular CDMA code channel may be substantially isolated to a particular sector in which an associated mobile is operating. Thus, energy may be reduced in other sectors allowing for the use of additional CDMA code channels in those sectors before the interference power level is such that a capacity limit is reached. Therefore, it will be appreciated that a technical advantage of the present invention is to provide for greater trunking efficiency and the ability to serve more users.

In the preferred embodiment, the dynamic assignment of beams to cell sectors of the present invention is accomplished through the use of a switch matrix, or other means by which a signal path may be discontinued, associated with each beam. Each such means may be adjusted to provide a signal from its associated beam to any input of a base transceiver station (BTS) demodulation receiver (demodulation Rx).

In an alternative embodiment, the sectors of a multi-sectored cell may be dynamically sized by using adaptive array circuitry in combination with or in place of the above-mentioned multiple beam antenna circuitry. The adaptive array circuitry may be utilized to dynamically form radiation patterns for which the azimuthal width and length of a sector may be adjusted to provide the desired coverage and quality of signals by providing a desired phase and/or amplitude differential at antenna elements of an antenna array with respect to a signal radiated by these elements. Thus, by adjusting the relative amplitude and/or phase of a sector signal as provided to antenna elements of a cell site antenna array, the azimuth of a sector that is not being utilized to full capacity may be increased, for example. Accordingly, a communication device in another full sector may be provided with capacity from the azimuthally adjusted sector. Similarly, by forcing a hand off of a communication device from an otherwise full sector to another sector such as by decreasing the size of a sector radiation pattern currently serving the communication device to thereby exclude the communication device from the adjusted sector, signal quality may be increased, such as in an interference limited CDMA system. Thus, if a communication device is experiencing poor signal quality or is causing interference with another communication device, then it may be handed off to an adjacent sector, by adjusting the azimuth of the sector or sectors.

In a preferred embodiment of the present invention, attenuators are utilized to control signal amplitude as provided to inputs associated with the aforementioned demodulation Rx. Such attenuators may be included between the output of switch matrixes used to adjust signal paths and the inputs to the demodulation Rx, or may in fact replace the switch matrixes in providing the ability to discontinue the path of a particular signal to a particular input of the demodulation Rx.

Attenuators may be utilized to adjust the magnitude of the transmit signal to the mobile. Such adjusting results in the mobile receiving a lower power signal than would otherwise be transmitted, and this lower level signal is used to essentially fool the mobile into requesting a handoff to an adjacent sector or cell. Such artificially forced handing off of communications may be useful in providing capacity for another communication device in an otherwise full sector by handing off a communication device capable of communicating through an adjacent sector or cell. Similarly, the handing off may be useful in increasing signal quality by handing off a communication that, although the signal quality is within acceptable limits, is causing

interference to another communication device or is itself experiencing poorer signal quality than would be available at an adjacent sector or cell.

Moreover, provision of the aforementioned attenuators results in a technical advantage in the ability to adjust the sector's effective outboard reach or length, as referenced in the direction of propagation of the radiation. It shall be appreciated that reduction of the size of the sector thereby decreases the amount of interference sent into adjacent cells as communication devices operating within the adjusted sector are limited in the distance from the center of the cell that they may operate. As a result, the adjacent cells may open up their sectors into larger areas to serve more customers, thus a system of cells utilizing the present invention may be used to provide increased signal quality as well as increased capacity without increasing the number of channels available at each cell.

Alternatively, adaptive array circuitry may be used in addition to or in place of the attenuators to adjust the magnitude of the transmit signal to the mobile and thereby provide capacity for another communication device to be used in an otherwise full sector. This may be accomplished by forcing a hand off a communication device capable of communicating through an adjacent sector or cell. Attenuators in the adaptive array may be used to provide attenuation for longitudinal reach in addition to providing side lobe control for the radiation patterns formed with the adaptive array circuitry.

One technical advantage of the above approaches specific to CDMA is realized due to the fact that the mobile receiver unit has a fixed finite number of demodulators, allowing it to communicate with a finite number of cells at a given time. In a deployed CDMA network there will generally be locations where a large number of cells or sectors on the forward link will have strong signals present at the mobile. In situations such as this, if the number of signals that are present at the mobile exceed the number of receiver modules that are built into the mobile, the mobile will experience interference from the sectors that it is not able to assign a demodulation receiver to. The shaping mechanism for the cell of the present invention would allow system operators to reduce the number of servers to a given mobile to match, or more nearly match, the number of demodulation receivers that are in the mobile, reducing the overall interference. Another technical advantage of the present invention is realized in how CDMA systems originate a call from a mobile to the land line side of the network or vice versa. The origination or access process generally takes place with the mobile communicating with one cell site, rather than multiple cell sites. In this situation, it is preferable to have one

single dominant server, or one strong cell or sector able to serve the mobile. The ability to shape the coverage of particular cells of the present invention allows service providers to have a higher probability of providing a dominant server at any given location to support these call originations.

A still further technical advantage of the present invention, that would apply both to analog and to CDMA digital systems, is the ability to target specific coverage areas, such as office buildings, sport stadiums, and the like, where large numbers of users are likely to be congregating. Targeting coverage could be done for particular periods of time and then reconfigured at other times.

Another example of concentrating the coverage would be to adjust the beam to sector mapping such that the overall coverage of a cell was less than 360°. So as to provide all of the capacity for a given cell in some azimuth angle extent that was less than 360°, for example, a sport stadium or some other hot spot of traffic.

The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated by those skilled in the art that the conception and the specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized by those skilled in the art that such equivalent constructions do not depart from the spirit and scope of the invention as set forth in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIGURE 1A illustrates a typical prior art omni-cell arrange;

FIGURE 1B illustrates a typical prior art sectored cell arrangement;

FIGURE 2 illustrates a multi-beam cell utilized by the present invention;

FIGURE 3A illustrates a block diagram of a communication system wherein multiple beams are combined to provide various sector sizes according to a preferred embodiment of the present invention;

FIGURE 3B illustrates a block diagram of the combining of multiple beams for the forward link of a cell site transmitter to match the various sector sizes of the system illustrated in FIGURE 3A;

FIGURE 4A illustrates a reverse link block diagram of a communication system wherein multiple beams are dynamically combined to provide selectable sector sizes according to a preferred embodiment of the present invention;

FIGURE 4B illustrates a forward link block diagram of a communication system, wherein multiple beams are dynamically combined to provide selectable sector sizes according to a preferred embodiment of the present invention;

FIGURE 4C illustrates an alternative arrangement of delays in the forward link of FIGURE 4B;

FIGURE 5 illustrates a block diagram of a communication system wherein signals associated with multiple beams may be dynamically attenuated and combined to provide selectable sector sizing according to a preferred embodiment of the present invention;

FIGURE 6 illustrates a block diagram of a communication system wherein particular signals of interest may be dynamically routed and attenuated to provide selectable sector sizing according to a preferred embodiment of the present invention; and

FIGURES 7A and 7B illustrate block diagrams of a communication system wherein an adaptive array circuitry may be used to provide selectable sector sizing according to an alternative embodiment of the present invention.

DETAILED DESCRIPTION

The present invention provides a system and method for dynamically shaping sectors within a cell. Preferably, the shapable sectors will be composed of narrow beams so as to provide a convenient means by which sectors may be sized azimuthally. Such multiple beams may be provided by either a single multi-beam antenna or a plurality of co-located discrete antennas.

To enable a better understanding of the advantages of the present invention, a brief description of some relevant prior art is included hereinafter. Directing attention to FIGURE 1A, a typical prior art cellular pattern is illustrated by communication arrays 121 through 123 disposed to communicate in predefined areas, or "cells," illustrated as cells 101 through 103. These cells are omni directional cell sites as the signal can be utilized in an entire 360° radius about the cell site.

As illustrated, a cell footprint is fixed by its forward channel radiated power, illustrated here as radius r. As can be seen by areas 111 through 113, there is some overlap between the radiation patterns of arrays 121 through 123 in order to provide the desired communication coverage within the cells.

The overlapping areas of communication coverage cause the potential for interference between communication devices operating within the cells. Therefore, interference, such as frequency reuse interference, is likely to be experienced when a communication device is operating within or near the area of overlap as the energy of the cell in which the mobile is communicating and that of the adjacent cell are combined as the interference power level.

A prior art solution to this problem has been to implement a sectored cell arrangement as is illustrated in FIGURE 1B. In this arrangement a single communication array provides communication in several defined sectors. For example, communications arrays 150, 160, and 170 are adapted to provide three discrete radiation patterns in predefined areas, or "sectors," illustrated as sectors 151 through 153, 161 through 163, and 171 through 173 respectively. The cells defined by this system are sector cell sites wherein the interference power level is distributed among the sectors.

Directing attention to FIGURE 2, a multi-beam cell site utilized by the preferred embodiment of the present invention is illustrated. Here 360° communication about cell site 200, and within cell 201, is accomplished by using multiple narrow beams illustrated as beams 210 through 221. Systems implementing such narrow beams are described in U. S. Patent

Number 5,563,610, entitled "NARROW BEAM ANTENNA SYSTEM WITH ANGULAR DIVERSITY," and the associated co-pending and commonly assigned continuation-in-part U. S. Patent application entitled "APPARATUS, SYSTEMS AND METHODS FOR MULTIPLE ANTENNA TRANSMISSION IN WIRELESS COMMUNICATIONS SYSTEMS," both of which have been previously incorporated by reference.

It shall be appreciated that, although a preferred embodiment includes twelve narrow beams, any number of beams may be utilized according to the present invention. Of course, the number of beams, and thus their azimuthal width, utilized by the system will directly impact the minimum width of a shapable sector achievable by the present invention.

Taking for example the preferred embodiment wherein a twelve beam system is used, the azimuthal width of a single sector can be reduced to 60° where a demodulation Rx having two inputs per sector is used. This sector size is accomplished by feeding two substantially non-overlapping 30° beams, instead of the signal provided by two substantially overlapping 120° antennas of the prior art, into the demodulation Rx for this particular sector. The same azimuthal width might also be selected for a second sector, leaving the third sector having a width of 240°.

Of course, the azimuthal width of a single sector may be reduced to 30° where a single 30° beam is fed into the sector input of a demodulation Rx. However, the advantages of signal diversity are not realized in such a sector. Therefore, the preferred embodiment of the present invention utilizes at least two beams per sector.

FIGURE 3A illustrates an implementation resulting in the above described three sector system having two 60° sectors and one 240° sector. With reference to FIGURE 3A, demodulation Rx 300 is a typical prior art CDMA demodulation radio having two inputs per sector. Here the inputs associated with a first sector are identified as inputs 1_1 and 1_2. Likewise, the inputs associated with a second and third sector are identified as inputs 2_1 and 2_2 and 3_1 and 3_2 respectively. Therefore, where beams 1 through 12 are associated with a 12 beam system, wherein each beam has a 30° azimuthal width such as illustrated in FIGURE 2, the sector sizing is as described above. Specifically, sector 1 having a 30° beam 1 and a 30° beam 2 associated with inputs 1_1 and 1_2 provides a 60° sector. Similarly, sector 2 having a 30° beam 3 and a 30° beam 4 associated with inputs 2_1 and 2_2 provides a 60° sector.

As demodulation Rx 300 only provides two inputs per sector, additional circuitry is necessary in order to input the plurality of beams remaining as a third sector. In a preferred

embodiment, signal combiners 350 and 351 are utilized to combine the signals provided by the remaining beams of the system into the proper number of discrete signals suitable for input into the demodulation Rx utilized by the present invention.

Through the use of signal combiners, sector sizing is accomplished by summing together the beam signals so as to increase the size of the sector signal provided to the demodulation Rx. Of course, where a demodulation Rx having a sufficient number of inputs to accommodate such a plurality of signals is utilized, the use of additional circuitry, such as combiners 350 and 351, may be eliminated, if desired. Likewise, the use of circuitry other than signal combiners, such as multiplexers, may be utilized according to the present invention, if desired. However, it shall be appreciated that the signal combiners are utilized in the preferred embodiment as signals from the various combined beams are provided to the demodulation Rx simultaneously, providing simultaneous communication throughout the beams of the sector, rather than in time division multiple access (TDMA) format as is the case in the use of a typical multiplexer. Of course, where TDMA signals or multiplexing by other schemes, such as frequency division multiple access (FDMA), are acceptable, multiplexers may replace the signal combiners of the preferred embodiment.

Because the cell site radio utilizes both forward and reverse links, circuitry providing forward link sector sizing consistent with that of the reverse link discussed above may also be provided. For example, where the transmit path utilizes different code channels per sector, the circuitry illustrated in FIGURE 3B may be utilized to transmit these forward path channels within the same sectors as those of the reverse link illustrated in FIGURE 3A.

It shall be appreciated that the circuitry of FIGURE 3B is substantially the same as that of FIGURE 3A. However, as typical prior art transmit forward path radios generally have only one output per sector, all beams associated with a particular sector are coupled to this output. For example, the three sector outputs of cell site Tx 370 illustrated in FIGURE 3B each include combiners to provide an output signal to sectors including the same number of beams as the reverse link illustrated in FIGURE 3A. Specifically, combiners 361 and 362 provide signals to beams 1 and 2, and 3 and 4 respectively. Likewise, combiner 363 provides signals to beams 5 through 12.

It shall be appreciated that such a system is advantageous where the users of a particular cell are more heavily concentrated within a particular area within the cell rather than evenly distributed throughout. Such usage patterns may be experienced, for example, where a

cell is located to include a commuter highway in its radiation pattern, or is located on the edge of a metropolitan area. Such cells might experience heavy user densities in particular areas as the user population commutes to and from work.

It shall be appreciated from the above discussion, that usage patterns which may advantageously be addressed by the present invention may change at various times of the day or week. For example, the previously described cell overlapping a commuter highway may see heavy utilization in a particular area during worker commuting times, and a more evenly distributed utilization pattern at other times. Similarly, a cell placed at the edge of a metropolitan area may see heavy utilization in an area encompassing the metropolitan area during working hours and heavy utilization in an area outside the metropolitan area during non-working hours. Therefore, it becomes obvious that further advantage may be realized by the system of the present invention by providing means by which the sizable sectors may be dynamically adjusted to accommodate the varying utilization patterns of a cell.

FIGURE 4A illustrates a preferred embodiment of the interface of signals from the various beams of a multi-beam system into a demodulation receiver, enabling a flexible sector/cell system of a preferred embodiment of the present invention. Here, as in the system illustrated in FIGURE 3A described above, signal combiners are provided to allow the input of multiple beams into the sector inputs of demodulation Rx 400 having M sectors. However, it shall be appreciated that, in order to provide for the input of a signal associated with any beam to any sector input, a signal combiner, illustrated as combiners $450a_1$, $450a_2$, $450b_1$, $450b_2$, $450m_1$, and $450m_2$, is associated with each sector input of demodulation Rx 400.

Furthermore, in order to provide a signal at any combination of the above described combiners, and thus the associated sector input of demodulation Rx 400 (i.e., providing the same signal at a plurality of sector inputs simultaneously), signals from the N beams are provided to splitter/switch matrixes associated with each beam, illustrated here as splitter/switch matrix 410a, 410b, and 410n. It shall be appreciated that each splitter/switch matrix splits the signal of an associated beam so as to be available for switchable connection to any combination of the aforementioned combiners. For example, the signal associated with beam 1 may be split M ways (so as to be available for input to signaling/scan Rx inputs associated with each of the M sectors) and be switchably connected to any combination of combiners by splitter/switch matrix 410a.

Of course, the function of the disclosed splitter/switch matrixes may be accomplished by utilizing a separate splitter in combination with a switch matrix having the proper number of inputs and outputs to provide for the switching of a signal associated with a beam to any combination of combiners. Moreover, signal amplification circuitry may be included in, or in addition to, the splitter circuitry of the preferred embodiment to provide a split signal having an acceptable magnitude. Such signal amplification may be provided in order to present each signal component of the original signal at a power level, or magnitude, substantially the same as the signal prior to its being split. Likewise, such signal amplification may be to present a split signal having a sufficient power level, or magnitude, to provide an acceptable signal to noise ratio. Where the original signal is split to provide a large number of split signal components, such amplification may be necessary in order to provide a signal having an acceptable signal to noise ratio to the inputs of demodulation Rx 400.

Of course, where it is not desired to provide the signal associated with a particular beam to more than one signal combiner, and thus its associated sector input, the splitter/switch matrixes of the present invention may omit the functionality of signal splitting, if desired. However, it shall be understood that omission of signal splitting, or a similar method of provision of multiple instances of the same signal information, is at the cost of the ability to provide overlapping coverage by the various sectors as is discussed hereinbelow.

Additionally, where it is not desired to allow for the input of a signal associated with each beam of the system to all sector inputs of the demodulation Rx, the number of outputs of the splitter/switch matrixes, as well as their associated combiner inputs, may be less than the total number of beams. However, it shall be appreciated that such a system is limited in ability to size a sector as the sector size is a function of the beam width and in the preferred embodiment of the number of beams combined into a sector input.

By properly adjusting the splitter/switch matrixes of the preferred embodiment of the present invention, various predetermined sector sizes may be realized. For example, the aforementioned combination of two 60° sectors and a single 240° sector may be realized in the following manner. By adjusting splitter/switch matrix 410a, the signal of beam 1 may be provided exclusively to combiner $450a_1$ associated with a first input of sector 1. Likewise, by adjusting splitter/switch matrix 410b, the signal of beam 2 may be provided exclusively to combiner $450a_2$ associated with a second input of sector 1. By similarly adjusting a second pair of splitter/switch matrixes (not shown, but represented by the ellipsis between

splitter/switch matrixes 410b and 410n), associated with a third and fourth beam (not shown, but represented by the ellipsis between beams 2 and N), a second 60° sector may be defined. Similarly, adjusting an additional eight splitter/switch matrixes, associated with a remaining eight beams of a twelve beam system, such as that illustrated in FIGURE 2, a third 240° sector may be defined. However, in this third sector, it shall be appreciated that adjusting of the remaining eight splitter/switch matrixes results in a combination of four beam signals switched to each of the two combiners associated with the third sector, illustrated here as combiners $450m_1$ and $450m_2$.

It shall be appreciated that the aforementioned arrangement has established a system wherein two 60° sectors and a single 240° sector, as described above with reference to FIGURE 3A. However, it shall be appreciated that the splitter/switch matrixes of the embodiment illustrated in FIGURE 4A, may be adjusted to provide sectors of sizes different than those described above.

Of course, selection of the size of the various sectors of the present invention may be made by manually adjusting the splitter/switch matrixes. Such manual adjustment may be acceptable where, for example sector sizes are rarely, if ever, changed. However, as discussed above, it is envisioned that the sectors of the present invention will advantageously be adjusted depending on different utilization patterns throughout any given day or week. Therefore, in a preferred embodiment, a control signal is provided to adjust splitter/switch matrixes 410a through 410n in order to dynamically select sector sizes.

Referring to FIGURE 4A, a control signal is provided to each splitter/switch matrix by sector controller 460. It shall be understood that, although a single control interface is illustrated between all of the splitter/switch matrixes, each of these splitter/switch matrixes may be controlled independently by controller 460. Of course, sector controller 460 need not be a discrete component associated with the cell site, but may instead be an integral part of the cell's existing control circuitry. Moreover, sector controller 460 may be included as a part of a centralized control system, utilized to control a network of neighboring cell sites, rather than being embodied within the particular cell site it is associated with.

Sector controller 460 may comprise a processor-based system having a processing unit (CPU) and memory associated therewith (RAM). The RAM may have stored therein an algorithm operable to cause the CPU to adjust the splitter/switch matrixes of the present invention to switchably connect the signals of the various beams to predetermined ones of the

sector inputs at various times of the day or week. Such an algorithm may be based on past or projected utilization patterns and incorporate no information on the actual utilization pattern of the cell.

Alternatively, as utilization patterns are often unpredictable and subject to change unexpectedly, in a preferred embodiment, sector controller 460 includes current utilization information, such as may be determined by controller 460 or may be provided by the cell's existing control circuitry. This current utilization information may include such information as the number of users associated with particular sectors, the number of available channels, or other resources, of particular sectors, or the signal quality associated with particular sectors or particular users within the sectors.

In addition, beams to sector mapping can be accomplished based on measurements of the received power, transmitted power, or transmitted signal to interference ratio per beam or per sector. For example, signals associated with each antenna beam may be split, such as by splitters 470-1 through 470-N, for provision to signal attribute measuring circuitry, such as Rx power measurement circuitry 471-1 through 471-N. Accordingly, a power level, or other signal attribute of interest, may be measured for each communication channel and/or beam. This information may then be provided to sector controller 460 for use in beam to sector mapping according to the present invention. From any combination of the above discussed information, sector controller 460 may adjust the splitter/switch matrixes of the present invention to provide alternative sector sizing and thus increase the number of channels, or other resources, available to a particular area within the cell, or improve signal quality associated with a sector or user.

Additionally, or in the alternative, sector controller 460 may be provided with current utilization information from a centralized apparatus (not shown) controlling a plurality of neighboring cells. Such a centralized apparatus may be provided information from each of the neighboring cells in order to make decisions as to the allocation of the various resources of the system, such as the re-use of channels at neighboring cells, the handing off of users between the cells, and the sizing of sectors at neighboring cells to provide increased capacity or signal quality. Management of such a system within a neighborhood of cells is disclosed in the above referenced co-pending and commonly assigned U. S. Patent application entitled "METHOD AND APPARATUS FOR IMPROVED CONTROL OVER CELLULAR SYSTEMS."

It shall be appreciated that, as discussed above, communication within a particular sector of a cell of a cellular system is not only a function of other communications within that sector or even other sectors of that cell, but may also be affected by communications within neighboring cells. Therefore, an alternative embodiment of the present invention includes means by which to adjust the sector's effective outboard reach or length, as referenced in the direction of propagation of the radiation. It shall be appreciated that reduction of the longitudinal size of the sector thereby decreases the amount of interference sent into adjacent cells as communication devices operating within the adjusted sector are limited in the distance from the center of the cell that they may operate. As a result, the adjacent cells may open up their sectors into larger areas to serve more customers. Thus, a system of cells utilizing the present invention may be used to provide increased signal quality as well as increased capacity without increasing the number channels available at each cell.

The above mentioned sector outboard shaping may be accomplished by putting attenuators (not shown) in the signal path between an antenna element associated with a particular beam and the signal's input into the signaling/scan Rx, such as between each output of splitter/switch matrix 410a and the associated inputs of combiners $450a_1$ through $450m_2$. These attenuators may be controlled as described above with respect to the splitter/switch matrixes to attenuate a selected signal in order to accomplish a particular control characteristic, i.e., force a handoff of a particular mobile unit between sectors or cells. Such attenuators may be utilized to adjust the power of a transmitted signal prior to its input into the mobile Rx. Therefore, the mobile Rx may be convinced that a particular beam is providing a lower input signal strength than would otherwise be the case. As such, the mobile Rx can be artificially manipulated to either cause an in sector handoff or a handoff to another cell. Of course, these attenuators may be manually adjusted, rather than under control of an automated control system such as sector controller 460, if desired. Accordingly, the outboard reach of a particular beam may be substantially permanently selected or seasonally selected in order to provide a desired service area.

In order to provide for sector shaping in the forward path, i.e., where the transmit path utilizes different code channels per sector, switchable circuitry is preferably also disposed in the transmit signal path. Directing attention to FIGURE 4B, a preferred embodiment of the switchable circuitry in the transmit path is shown. Here, the three sector outputs of the cell site Tx, such as that illustrated in FIGURE 3B, are input into switch matrix 480. Switch matrix

480 is adapted with a suitable number of inputs and outputs in order to be able to switchably provide any combination of the sector signals to any of the antenna beams. In a preferred embodiment, switch matrix 480 is a 3 x 12 switch matrix. Of course, any combination of inputs and outputs switchable for providing the desired number of transmit signals to the desired number of antennas may be used. Moreover, discrete switch matrixes associated with the sector transmit signals or antenna beams may be utilized, rather than the single switch matrix illustrated, if desired.

It shall be appreciated that switch matrix 480 is coupled to a controller, in order to properly map the transmit signals of each of the cell site Tx to the desired beams. Preferably, sector controller 460 is utilized to control switch matrix 480, as this controller may be economically utilized to control both the receive sector and transmit sector sizes utilizing much of the same information. Of course, separate controllers, or controllers operating substantially independently, may be utilized in the transmit and receive signal paths, if desired.

As discussed above, it may be desirable to adjust the magnitude of the transmit signal to the mobile in order to effect the outboard reach of the cell site with respect to a particular signal or in a particular beam. Accordingly, attenuators, such as those discussed above with respect to the receive signal path, may be placed in the transmit signal path. Directing attention again to FIGURE 4B, a preferred embodiment of attenuators, disposed in the transmit signal path are illustrated as attenuators 484-1 through 484-12. As with the attenuators of the receive path, attenuators 484-1 through 484-12 may be controlled by sector controller 460. Therefore, in a preferred embodiment, transmit signal splitters, such as splitters 481-1 through 481-12, are used to split a transmit signal associated with each beam for provision to a measurement circuit, such as Tx measurement circuits 482-1 through 482-12. Tx measurement circuits 482-1 through 482-12 may make such measurements as a total amount of energy associated with a particular beam or a particular signal to be transmitted by a particular beam. This information may be utilized by a controller adapted to control attenuators 484-1 through 484-12, such as sector controller 460, in order to attenuate a signal to be transmitted by a particular beam. Such adjustments may be added so as to result in a selected mobile receiving a lower power signal from the cell site than would otherwise be transmitted and, thus, fool the mobile into requesting a handoff. Accordingly, the present invention may operate to force a handoff of a particular mobile that may be adequately serviced by an adjacent sector or cell in

order to free up capacity for another mobile unable to adequately communicate with another sector or cell.

Of course, rather than the attenuators in the transmit signal path operating under control of sector controller 460, they may receive control signals from other sources as discussed above. Likewise, these attenuators may be manually adjusted to provide desired cell coverage substantially permanently or adjusted periodically, such as seasonally.

As typical prior art transmit forward path radios generally have only one output per sector, a preferred embodiment of the present invention utilizes delays introduced in the transmit signal path. Directing attention to FIGURE 4B, a preferred embodiment of delays disposed in the transmit signal path are illustrated as delays 483-2 through 483-12. These delays may be any form of signal delay device, such as surface acoustic wave device (SAW), a predetermined length of cable, a digital signal processor (DSP), or the like.

According to a preferred embodiment of the present invention, a transmit signal associated with a particular sector, originally appearing in a signal sector signal from the cell site Tx, is provided to at least two antenna beams to provide for transmit diversity, in addition to the adjustable sector sizing of the present invention. In order to provide an increased likelihood of the split sector transmit signal, as transmitted within the two or more antenna beams, will not be substantially correlated, a delay is introduced in at least one of the split signal paths. It is anticipated that the antenna beams associated with a particular sector will typically be adjacent, so as to define a contiguous sector. Therefore, the delays of the present invention are preferably disposed in alternating ones of the transmit signal paths, as illustrated in FIGURE 4B. Accordingly, signals radiated within adjacent beams will be provided with signal diversity in addition to the angular diversity provided by the different views of the beams. Of course, where a sector is defined to utilize more than two beams, the signals of alternating ones of the beams will be provided with an identical delay. However, this is not anticipated to effect the desired diversity adversely as the angular diversity of alternating ones of the beams is acute enough to provide sufficient signal diversity. Of course, each beam, or subsets thereof, may be provided with different amounts of delay in the transmit signal path, if desired.

An alternative embodiment of the introduction of various delays in the transmit signal path is illustrated in FIGURE 4C. Here a portion of the forward link system shown in FIGURE 4B is shown utilizing switches 485-1 through 485-12 and 486-1 through 486-12 to

selectively switch delays 483-1 through 483-12 in or out of their respective signal paths. Accordingly, an arbitrary arrangement of delays in the transmit signal paths preferably selected so as to result in substantially uncorrelated signals, may be dynamically selected. Switches 485-1 through 485-12 and 486-1 through 486-12 may operate under control of sector controller 460, or another control system, in order to selectively switch into the various transmit signal paths an amount of delay to result in substantially uncorrelated signals when received by mobiles operating within the cell.

It shall be appreciated that the alternative embodiment of FIGURE 4C may include selectable delays in addition to the single delay for each signal path shown. Accordingly, various delay amounts might be selected for beams assigned to a particular sector, for example. Moreover, delays 483-1 through 483-12 may each be selected to introduce a different amount of delay, if desired.

Directing attention to FIGURE 6, an alternative embodiment of the present invention is illustrated suitable for providing the signals of the two beams to demodulation Rx 400. It shall be appreciated that this embodiment does not utilize combiners $450a_1$ through $450m_2$.

Because only the beams having the strongest receive signal of interest are switched to the input of demodulation Rx 400, the number of switch matrixes utilized in this embodiment is associated with the number of sector inputs of demodulation Rx 400 rather than the number of beams as in the above described embodiment. Therefore, in order to provide a signal from any beam to a selected sector input of demodulation Rx 400, signals from each of the N beams are provided to switch matrixes associated with each sector input; illustrated here as switch matrixes $610a_1$ through $610m_2$. It shall be appreciated that the use of such switch matrixes may be utilized to provide signals from any beam to multiple sector inputs simultaneously and, thus, provide overlapping coverage by the various sectors as is discussed hereinbelow. Moreover, this arrangement of switch matrixes may be utilized in the transmit signal path (not shown) to provide the sector beam mapping of the present invention by coupling switch matrixes between the outputs of the cell site Tx and the multiple antenna beams. Of course, to provide the desired transmit signal diversity, delays may be disposed in the signal path. Preferably, such delays are provided in alternating ones of the signal paths between the switch matrixes and the antennas associated with each of the beams, i.e., between switch $610a_1$ and beams 2, 4,...N.

As in the embodiment discussed above, the switch matrixes of this embodiment are controlled by a control signal provided each switch matrix by sector controller 460. It shall be understood that, although a single control interface is illustrated between all of the switch matrixes, that each of these switch matrixes is controlled independently by controller 460. Of course, sector controller 460 need not be a discrete component associated with the cell site, but may instead be an integral part of the cell's existing control circuitry. Moreover, sector controller 460 may be included as a part of a centralized control system, utilized to control a network of neighboring cell sites, rather than being embodied within the particular cell site it is associated with.

As with the above discussed embodiment, sector controller 460 may comprise a CPU and RAM to control the sectors according to the present invention, such as through the use of an algorithm basing switching decisions on past or projected utilization patterns or an algorithm basing such decisions on current utilization as determined from this cell or a neighborhood of cells. Current utilization information may be determined by controller 460 or may be provided by the cell's existing control circuitry. Sector controller 460 may also be provided with current utilization information from a centralized apparatus (not shown) controlling a plurality of neighboring cells. As discussed in detail above, this current utilization information may include such information as the number of users associated with particular sectors or cells, the number of available channels, or other resources, of particular sectors or cells, or the signal quality associated with particular sectors, cells or users.

It shall be appreciated that, as discussed above, communication within a particular sector of a cell of a cellular system is not only a function of other communications within that sector or even other sectors of that cell, but may also be affected by communications within neighboring cells. Therefore, this embodiment of the present invention includes means by which to adjust the sector's effective outboard reach or length, as referenced in the direction of propagation of the radiation. It shall be appreciated that reduction of the longitudinal size of the sector thereby decreases the amount of interference sent into adjacent cells as communication devices operating within the adjusted sector are limited in the distance from the center of the cell that they may operate. As a result, the adjacent cells may open up their sectors into larger areas to serve more customers. Thus, a system of cells utilizing the present invention may be used to provide increased signal quality as well as increased capacity without increasing the number channels available at each cell.

The above mentioned sector outboard shaping in the receive link is preferably accomplished through adjusting attenuators $650a_1$ through $650m_2$ provided in the signal paths between the switch matrixes and the demodulation Rx inputs. These attenuators may be utilized to adjust the power of a transmitted signal prior to its input into the demodulation Rx. As described above with respect to the switch matrixes, each of the attenuators may be individually controlled by controller 460. Therefore, the cell site may be convinced that a particular signal is being received at a lower strength than would be received otherwise. As such, the cell site can be artificially manipulated to either cause an in-sector handoff or a handoff to another cell.

The above mentioned sector outboard shaping in the transmit link is preferably accomplished through adjusting attenuators or signal gain devices, such as attenuators $650a_1$ through $650m_2$, provided in the signal paths between the switch matrixes and the mobile Rx. These attenuators may be utilized to adjust the power of a transmitted signal prior to its transmission to the mobile Rx. As described above with respect to the switch matrixes, each of the attenuators may be individually controlled by controller 460. Therefore, the mobile Rx may receive a signal at a lower strength than would be received otherwise. As such, the mobile Rx can be artificially manipulated to either cause an in sector handoff or a handoff to another cell.

It shall be appreciated, although outboard shaping may be accomplished through the use of attenuators with either of the above described embodiments, that the alternative embodiment illustrated in FIGURE 6 utilizes a number of such attenuators equal to the sector inputs of demodulation Rx 400. Such an arrangement of attenuators allows the sector controller to adjust a signal strength of the signal of interest independently at any or all of the sector inputs.

However, in order to independently adjust a signal strength of the signal of interest independently at each of the sector inputs with the embodiment illustrated in FIGURE 4, the number of attenuators must equal the number of beams times the number of sector inputs. This is because if fewer attenuators were used, such as by placing them between the beam signal source and the splitter/switch matrixes 410a through 410n or between combiners $450a_1$ through $450m_2$ and the sector inputs, the signal strength for multiple sector inputs or for multiple beams would be adjusted rather than their being independently adjusted. The former would result in all signals received on a particular beam being adjusted similarly regardless of the sector input

it is to be input into. The latter would result in all signals input into a sector input being adjusted similarly regardless of the beam from which it originated.

It shall be appreciated that attenuation of ones of the various signals associated with the beams of the present invention effectively decreases the outboard, or longitudinal, size of the sector including that beam, thereby decreasing the size of the sector or cell. For example, increasing the amount of the attenuation of an attenuator associated with a particular beam, which translates into a reduction in signal strength of that beam, which beam's signal is routed to a particular input port of the demodulation Rx results in the reduction of the range of this antenna beam of the system as seen at the input port of the demodulation Rx. In the aforementioned combination of two 60° sectors and a single 240° sector, for example, the signals on the two antenna beams forming the 60° sector could be attenuated by a select amount and thus, reduce the range of this particular sector of the cell to a predetermined length.

The above mentioned forced handoff of users of a particular sector/cell by attenuating the signal received or transmitted to from the user may be advantageous where the handed off user, or other user of the cell, has an interference problem, such as might be caused by frequency reuse interference or an undesirable carrier to noise ratio. The forced handoff of a particular user could be utilized to improve signal quality by providing the user with a better signal from another sector/cell.

For example, where there is interference as a result of using certain channels on the two beams comprising the above discussed 60° sector, by utilizing attenuators in the signal paths an effective reduction in the size of that specific sector could be accomplished. As a result of the reduced effective sector size, communication devices in the sector would be handed off to be serviced by an adjacent sector or cell, thereby reducing the interference that this sector is causing other users.

Recognizing that interruption in a signal path may be accomplished by an attenuator adjusted to provide impedance approaching infinity, or an open circuit, an alternative preferred embodiment of the present invention utilizes attenuators exclusive of switch matrixes, as is illustrated in FIGURE 5. Of course, as previously discussed, attenuators can be utilized within the signal paths of the switches of FIGURES 4A, 4B or 6 to provide signal attenuation in addition to signal switching, if desired.

Referring to FIGURE 5, it can be seen that signals associated with the various beams are provided demodulation Rx 400 through the signal combiners $450a_1$ through $450m_2$ as in the

embodiment illustrated in FIGURE 4A. However, the splitter/switch matrix of the previously discussed embodiment have been replaced with splitters 510a through 510n in combination with attenuators $520a_1$ through $520m_2$, $530a_1$ through $530m_2$, and $540a_1$ through $540m_2$. Of course, the splitters and associated attenuator sets may be combined into a single apparatus, much like the splitter/switch matrixes of FIGURE 4A, if desired.

Referring again to FIGURE 5, a control signal is provided to each attenuator by sector controller 460. It shall be appreciated, although a single control interface is illustrated between controller 460 and the attenuators of this embodiment, that each of the attenuators may be independently adjusted by sector controller 460. As in the above described embodiment, sector controller 460 need not be a discrete component associated with the cell site, but may instead be an integral part of the cell's existing control circuitry. Similarly, sector controller 460 may be included as a part of a centralized control system, utilized to control a network of neighboring cell sites, rather than being embodied within the particular cell site it is associated with.

As previously mentioned, sector controller 460 may comprise a CPU and RAM. This RAM may have stored therein an algorithm operable to cause the CPU to adjust the attenuators of the present invention to increase their impedance to approach infinity, to result in a discontinuation of a particular signal path, or to decrease impedance, to result in variously attenuated signal paths ("switching"). It shall be appreciated that such adjustment results in the switching of the signals of the various beams, at various power levels, to predetermined ones of the sector inputs. Such switching may be at various times of the day or week as was the case in the aforementioned embodiment.

Switching by such an algorithm may be based on past or projected utilization patterns and incorporate no information on the actual utilization pattern of the cell. Alternatively, in a preferred embodiment, sector controller 460 includes current utilization information input such as may be determined by controller 460 or may be provided by the cell's existing control circuitry. This current utilization information may include such information as the number of users associated with particular sectors, the number of available channels, or other resources, of particular sectors, and the signal quality associated with particular sectors or particular users within the sectors. From this information, sector controller 460 may adjust the attenuators of the present invention to provide alternative sector sizing, either by establishing/discontinuing a signal path associated with a particular beam to a particular sector input or by

increasing/reducing the effective longitudinal size of beams of a particular sector, and thus increase the number of channels, or other resources, available to a particular area within the cell, or improve signal quality associated with a sector or user.

Additionally, or in the alternative, sector controller 460 may be provided with current utilization information of a plurality of neighboring cells from a centralized apparatus as described above. Such a centralized apparatus may be provided information from each of the neighboring cells in order to make decisions as to the allocation of the various resources of the system, such as the re-use of channels at neighboring cells, the handing off of users between the cells, and the sizing of sectors at neighboring cells to provide increased capacity or signal quality.

It shall be appreciated that, although the use of two 60° and one 240° sector has been discussed in the above examples, such sector sizing is purely in the way of example and is in no way intended to be a limitation of the present invention. Any number of beams may be composited into sectors according to the present invention. For example, the present invention could be utilized to provide a single 60° sector concurrent with two 150° sectors. Likewise, the present invention is equally suited to provide homogeneous sectors, such as the three 120° sectors of the prior art systems.

Additionally, it is also possible, according to the present invention, to provide all of the beams to each sector input to essentially provide an omni cell site. For example, in the twelve beam system described herein, signals from all twelve beams would be provided to inputs associated with each sector of the demodulation Rx. Likewise, all beams could be associated with the transmit sector signals of cell site Tx. Here, instead of having 120° per sector as in the prior art, each sector covers a full 360°, or using the above described two input demodulation Rx, 180° per each sector input. For example, using every other beam for input number 1 and every other beam for input number 2 associated with a first sector, this first sector now covers a full 360° about the cell site. Similarly, the two inputs associated with the remaining sectors may be provided signals from each beam. This results in each sector having 360° azimuthal coverage in the back tune configuration and, therefore, each channel, regardless of the sector with which it is associated, being available throughout the cell.

Similarly, it is also possible to combine signals from the same beams into sector inputs of two or more sectors to essentially provide overlapping sectors of various sizes. For example, in the twelve beam system described herein, signals from six of the beams could be

provided to inputs associated with the first two sectors of the demodulation Rx. Here, instead of having 120° per sector as in the prior art, each sector covers 180°; the first and second sector providing 180° overlapping coverage and the third sector providing coverage for the remaining 180°. For example, using every other beam of the first six beams for input number 1 and the remaining beams of this six for input number 2 associated with a first sector, this first sector now covers 180° about the cell site. Likewise, using every other beam of the first six beams for input number 1 and the remaining beams of this six for input number 2 associated with a second sector, this second sector also covers the same 180° about the cell site as the first sector. Coverage for the remaining 180° may be provided by using every other beam of the last six beams for input number 1 and the remaining beams of this six for input number 2 associated with a third sector. Such overlapping sector configurations provide the channels associated with each overlapping sector throughout the area of overlap.

Although the use of alternating adjacent beams has been discussed with respect to the two inputs associated with a particular sector of the demodulation Rx, it shall be appreciated that the present invention is not limited to such an arrangement. Signals from adjacent beams may be combined by a signal combiner to the same input of a sector input pair according to the present invention.

However, it shall be appreciated that inputting adjacent beam signals to alternate inputs of a sector input pair is preferred so as to provide a better quality signal by increasing signal diversity between the signals input to each input of the sector input pair. Through the angular diversity associated with the collocated beam sources disposed to "see" different wave fronts, adjacent beam signals provided to alternate inputs of a sector input pair may provide signal diversity where adjacent beam signals provided to the same inputs of a sector input pair may not. For example, where a communication device is located such that its signal is received only within two adjacent beams of a four beam sector, provision of these two adjacent beam signals to a single sector input would not provide signal diversity whereas alternating input of adjacent beams to the sector input pair of the demodulation Rx would provide signal diversity.

Furthermore, it shall be appreciated that, although a three sector system has been discussed, the present invention is not limited to the provision of three sectors. The present invention may provide dynamic sector sizing of any number of sectors controllable by the associated demodulation Rx and cell site Tx. For example, the present invention may provide two sectors rather than the three discussed. Similarly, the present invention may provide a

number of sectors in excess of the three sectors described in a preferred embodiment, such as is represented by the M sectors of demodulation Rx 400.

Similarly, it shall be understood that the present invention is not limited to the provision of two signals per sector input. By using various arrangements of the aforementioned switch matrixes and/or attenuators in combination with signal combiners (if needed), the present invention may provide a number of signals associated with particular beams to any number of sector inputs.

Furthermore, it shall be understood that the present invention is not limited to utilization of a twelve beam system as described herein. Any number of beams may be utilized to provide the dynamically sizable sectors of the present invention. Of course, where the number of beams utilized is different than discussed above, the individual beam width may be greater or less than the 30° beam width used in the above examples. Therefore, it shall be appreciated that use of a different number of beams may result in a different minimum sector width as a result of combining such beams.

Moreover, it shall be appreciated that the use of equally sized beams is not a limitation of the present invention. Beams of different azimuthal width may be utilized to provide the dynamically sizable sectors of the present invention. For example, where a particular area within a cell is likely to be utilized by only a limited number of users, such as where the cell overlays a mountainous region causing signal shadows or where the cell includes other areas of limited user access, i.e., an ocean, a few beams may be sized to substantially cover this area so as not to necessitate the provision of a number of beams for a very few possible users.

Although the present invention for antenna deployment sector cell shaping has been described above with regard to beam switching, it should be appreciated by those of skill in the art that the invention is not so limited. For example, in the embodiments shown in FIGURES 7A and 7B, adaptive array circuitry is used to provide the desired radiation patterns. The relative phase of signal components of the sector signals as provided to antenna elements of a cell site antenna array, may be adjusted to increase or decrease the azimuthal width of a sector of a multi-sectored cell according to the present invention. Similarly, the relative amplitude of signal components of the sector signals as provided to antenna elements of a cell site antenna array may be adjusted to change a sector's effective outboard reach or length as referenced in the direction of propagation of the radiation. The desired amplitude and phase adjustment of the sector signals may be accomplished according to communication parameters such as

information indicating the quality of the communication channel on a particular sector or group of sectors or the number of calls serviced in particular sectors.

Thus, in the forward link block diagram of a communication system using adaptive array amplitude and/or phase adjusting means as shown in FIGURE 7A, signals 1, 2, . . ., N are received by adaptive array circuitry 701 from N channels. The adaptive array circuitry 701 may comprise a Tx switch circuitry 702 and a Tx weight circuitry 703. The Tx weight circuitry 703 may include phase adjusting circuitry (not shown), such as phase adjusters, adjustable phase shifters, I/Q modulators, Surface Acoustic Wave (SAW) devices, PIN diode circuits, transmission line phase shifters, or the like. The Tx weight circuitry may also include amplitude adjusting circuitry (not shown), such as adjustable attenuators, adjustable amplifiers, stepped attenuators, PIN diode switched attenuators, variable gain stages, or the like, and/or any other circuitry for suitably manipulating signal components of signals as provided to antenna arrays 704a, 704b, . . ., 704m to provide the adjustable sector beam forming of the present invention. The phase adjusting circuitry may be used to adjust the relative phases of signal components of the sector signals as provided to antenna elements of antenna arrays 704a, 704b, . . ., 704m to change the azimuthal width of a sector. The width of the various sectors may be changed by manually adjusting the phase of the signal components of the signals in the adaptive array circuitry. Such manual adjustment may be acceptable where, for example, sector sizes are rarely, if ever, changed. However, as discussed above, it is envisioned that the azimuthal width and outboard length of the sectors in the present invention will advantageously be adjusted depending on different utilization patterns through any given day or week. Therefore, control signal 706 may be provided by controller 707 to the Tx weight circuitry 703 to adjust the relative phase and/or amplitude of signal components of a sector signal as provided to antenna elements of an antenna array. Thus, the sectors size may be dynamically adjusted by providing control signals to the Tx weight circuitry 703.

Controller 707 receives communication parameters such as information indicating the quality of the communication channel in any particular sector or the number of calls received in particular sectors. Controller 707 may also receive similar information from other sectors and also other cell sites. Based on this information, controller 707 may calculate the desired phase adjustments necessary to expand or reduce the width of a sector and may produce control signals 705, 706 that are fed to Tx switch circuitry 702 and Tx weight circuitry 703. Thus, Tx switch circuitry 702 may be used to switch particular signals to the desired inputs of Tx weight

circuitry 703 for adjustment by the amplitude and/or phase adjusting circuitry or any other circuitry of Tx weight circuitry 703. The adjusted signals are then fed to the antenna elements of the respective antenna arrays 704a, 704b, ..., 704m.

Thus, in this alternative embodiment of the present invention, in order to adjust the width of the sectors, the beams need not be switched from one sector to another. Instead the azimuthal width of a sector may be adjusted by changing the relative phase of signal components of a sector signal as provided to antenna elements of a cell site.

It shall be appreciated that, as discussed above, communication within a particular sector of a cell of a cellular system is not only a function of other communications within that sector or even other sectors of that cell, but may also be affected by communications within neighboring cells. Therefore, the sector's effective outboard reach or length, as referenced in the direction of propagation of the radiation, may also be adjusted. This may be accomplished by changing the relative amplitude of signal components of a sector signal as provided to antenna elements of an antenna array by the amplitude adjusting circuitry that may be included in Tx weight circuitry 703. Thus, communication parameters such as the quality of the communication channel in any particular sector received by controller 707 may be used to calculate the desired amplitude adjustments necessary to increase or decrease the effective outboard reach or length of any sector. Control signals 705, 706 may be used to transmit the desired values to the Tx switch circuitry 702 and Tx weight circuitry 703. Thus, the controller 707 may calculate the relative amplitude adjustments necessary to provide the desired outboard reach or length.

In order to provide for sector shaping in the reverse path, i.e. where the transmit path utilizes different code channels per sector, an adaptive array circuitry may also be disposed in the reverse signal path. Directing attention to FIGURE 7B, sector controller 707 is utilized to control adaptive array circuitry 701, as this controller may be economically utilized to control both the receiver sector and transmit sector sizes utilizing much of the same communication parameters, such as information indicating the quality of the communication channel on a sector. Of course, separate controllers, or controllers operating substantially independently may be utilized in the transmit and receive signal paths if desired. Thus, values for relative phase delays and amplitudes may be provided by controller 707 substantially as shown in the forward signal path.

Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the spirit and scope of the invention as defined by the appended claims. Moreover, the scope of the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one of ordinary skill in the art will readily appreciate from the disclosure of the present invention, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized according to the present invention. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.

WHAT IS CLAIMED IS:

1. A system for dynamically adjusting a sector size of a plurality of sectors of a radiation pattern, the radiation pattern impacting a communication apparatus having a plurality of signal interfaces, said system comprising:

an antenna system providing said radiation pattern having said plurality of sectors, wherein each sector has associated therewith a discrete sector signal, wherein said discrete sector signals are associated with particular signal interfaces of said plurality of signal interfaces of said communication apparatus;

sector shaping circuitry coupled to said antenna system providing adjustable forming of at least one sector of said plurality of sectors of said radiation pattern; and

a controller coupled to said sector shaping circuitry adapted to determine at least one of forward and reverse traffic loads across said plurality of sectors, wherein said controller is operable to periodically alter forming of said at least one sector in response to determinations of said at least one of forward and reverse traffic loads.

2. The system of claim 1, wherein said sector shaping circuitry is part of an adaptive array providing adjustable phase progression of components of said sector signal of said at least one sector adjustable with said sector shaping circuitry.

3. The system of claim 2, wherein a width of said at least one sector is at least in part defined as a function of a particular phase progression provided by said shaping circuitry.

4. The system of claim 2, wherein an azimuthal orientation of said at least one sector is at least in part defined as a function of a particular phase progression provided by said shaping circuitry.

5. The system of claim 2, wherein said sector shaping circuitry further provides adjustable weighting of said components of said sector signal, and wherein a width of said at least one sector is at least in part defined as a function of a weighting of said components of said sector signal provided by said shaping circuitry.

6. The system of claim 2, wherein said sector shaping circuitry further provides adjustable weighting of said components of said sector signal, and wherein an azimuthal orientation of said at least one sector is at least in part defined as a function of weighting of said components of said sector signal provided by said shaping circuitry.

7. The system of claim 2, wherein said sector shaping circuitry further provides adjustable weighting of said components of said sector signal, and wherein a length of said at least one sector is at least in part defined as a function of weighting of said components of said sector signal provided by said shaping circuitry.

8. The system of claim 1, wherein said sector shaping circuitry is part of an adaptive array providing relative amplitude adjustment of signal components of said sector signal of said at least one sector adjustable with said sector shaping circuitry.

9. The system of claim 8, wherein a length of said at least one sector is at least in part defined as a function of a particular amplitude progression provided by said shaping circuitry.

10. The system of claim 8, wherein said relative amplitude adjustment of signal components is dependent in part on information regarding at least one of said forward and reverse traffic load across said plurality of sectors.

11. The system of claim 1, wherein said controller comprises:
means for receiving from said communication apparatus information regarding a quality of communication on communication channels within a frequency utilized by said plurality of sectors, wherein said quality of communication information is utilized by said controller in periodically altering said at least one sector.

12. The system of claim 1, wherein said plurality of sectors utilize the same frequency.

13. The system of claim 12, wherein communication channels with said frequency are differentiated by a channel attribute.

14. The system of claim 13, wherein said channel attribute is selected from a group consisting of a code and a code delay.

15. The system of claim 2, wherein said adjustable phase progression of components is dependent in part on information regarding at least one of said forward and reverse traffic load across said plurality of sectors.

16. The system of claim 1, wherein ones of said plurality of sectors overlap, an amount of said sector overlap being a function of said adjustable forming of said at least one sector of said plurality of sectors.

17. The system of claim 1, wherein said periodically altering of forming of said at least one sector is also in response to external control signals provided to said controller.

18. The system of claim 17, wherein said external control signals are provided by a centralized controller operating to control a plurality of cooperating communication apparatus.

19. The system of claim 1, wherein said traffic load information comprises data pertaining to the relative traffic loading among said plurality of sectors.

20. The system of claim 1, wherein ones of said plurality of sectors overlap, said sector overlap being a function of a phase progression of components of said sector signals associated with said ones of said plurality of sectors.

21. The system of claim 1, further comprising:

means for storing phase delay values for signal components of ones of said sector signals, wherein said stored phase delay values are used to phase adjust said signal components of said ones of said sector signals.

22. The system of claim 1, further comprising:

means for storing amplitude values for signal components of ones of said sector signals, wherein said stored amplitude values are used to amplitude adjust said signal components of said ones of said sector signals.

23. A system for dynamically adjusting a sector size of a plurality of sectors of a radiation pattern, the radiation pattern associated with a communication device having a plurality of signal interfaces, said system comprising:

means for providing said plurality of sectors composited to form said radiation pattern, wherein ones of a plurality of signals are coupled to ones of said plurality of interfaces of said communication device, wherein a size of a sector of said plurality of sectors is at least in part defined as a function of a relative difference of at least one attribute of signal components of at least one of said plurality of signals coupled to a particular one of said plurality of interfaces;

means for determining at least one of forward and reverse traffic loads across said plurality of sectors; and

means controlled by said determining means for periodically altering said at least one attribute of ones of said plurality of signal components of at least one of said plurality of signals coupled to ones of said plurality of interfaces.

24. The system of claim 23, wherein said at least one attribute is a phase.

25. The system of claim 23, wherein said at least one attribute is an amplitude.

26. The system of claim 23, wherein said means for periodically altering is part of an adaptive array, wherein said means for periodically altering comprises:

means for adjusting phases of signal components of ones of said plurality of signals coupled to ones of said plurality of interfaces.

27. The system of claim 23, wherein said means for periodically altering is part of an adaptive array, wherein said means for periodically altering comprises:

means for adjusting amplitudes of signal components of ones of said plurality of signals coupled to ones of said plurality of interfaces.

28. The system of claim 23, wherein said means for determining, comprises:

a processor-based controller providing a control signal to said means for periodically altering, said control signal operable to cause said means for periodically altering to substantially automatically adjust an azimuthal width of ones of said plurality of sectors by adjusting a phase of select ones of signal components of select ones of said plurality of signals coupled to said ones of said plurality of interfaces.

29. The system of claim 28, wherein said control signal is further operable to cause said means for periodically altering to substantially automatically adjust a length of ones of said plurality of sectors by adjusting an amplitude of select ones of signal components of select ones of said plurality of signals coupled to said ones of said plurality of interfaces.

30. The system of claim 28, wherein said processor-based controller provides said control signal as a function of current communication traffic information.

31. The system of claim 28, wherein said control signal is a function of a signal provided to said processor-based controller by a centralized controller operating to control a plurality of communication devices.

32. The system of claim 23, wherein a width of at least one of said sectors is in part defined as a function of a particular phase progression provided by said means for periodically altering.

33. The system of claim 23, wherein ones of said plurality of sectors partially overlap, said sector overlap being a function of a phase progression of signal components of particular ones of said plurality of signals coupled to particular ones of said plurality of interfaces.

34. The system of claim 23, wherein said plurality of sectors utilize the same frequency, and wherein communication channels within said frequency are differentiated by a code.

35. The system of claim 23, wherein said determining means comprises information provided by a centralized controller operating to control a plurality of cooperating communication devices.

36. The system of claim 35, wherein at least one of said plurality of cooperating communication devices is a Code Division Multiple Access (CDMA) communication device.

37. A system for providing a plurality of variable size sectors in a radiation pattern including a plurality of sector radiation patterns, each sector radiation pattern providing a discrete sector input signal suitable for input into a demodulation receiver having a plurality of inputs, each sector radiation pattern also providing radiation of a discrete sector output signal, each of said sector output signals associated with at least one of a plurality of signal outputs from a cell site transmitter having a plurality of outputs, wherein at least one of said plurality of demodulation receiver inputs and at least one of said plurality of cell site transmitter outputs are associated with at least one sector of said plurality of sectors, said system comprising:

a plurality of sector input signal path control means for adaptively altering an attribute of signal components of ones of said sector input signals provided to select ones of said demodulation receiver inputs, wherein a sector of said plurality of sectors is at least in part defined as a function of a relative difference of said attribute of at least one of said signal components of ones of said sector input signals;

a plurality of sector output signal path control means for adaptively altering an attribute of signal components of ones of said sector output signals, wherein a sector of said plurality of sectors is at least in part defined as a function of a relative difference of said attribute of at least one of said signal components of ones of said sector output signals; and

control means for controlling said input signal path control means and said output signal path control means.

38. The system of claim 37, wherein said attribute is a phase.

39. The system of claim 37, wherein said attribute is an amplitude.

40. The system of claim 37, wherein an azimuthal size of each of said variable size sectors is a function of a phase differential of signal components of ones of said sector input signals provided to said at least one input of said demodulation receiver associated with a particular sector, wherein said phase differential is provided by ones of said plurality of sector input signal path control means.

41. The system of claim 37, wherein an azimuthal size of each of said variable size sectors is a function of a phase differential of signal components of ones of said sector output signals, wherein said phase differential is provided by ones of said plurality of sector output signal path control means.

42. The system of claim 37, wherein a longitudinal size of each of said variable size sectors is a function of an amplitude differential of signal components of ones of said sector input signals provided to said at least one input of said demodulation receiver associated with a particular sector, wherein said amplitude differential is provided by ones of said plurality of sector input signal path control means.

43. The system of claim 37, wherein a longitudinal size of each of said variable size sectors is a function of an amplitude differential of signal components of ones of said sector output signals, wherein said amplitude differential is provided by ones of said plurality of sector output signal path control means.

44. The system of claim 37, wherein at least one of said plurality of sector signal input path control means and at least one of said plurality of sector signal output path control means is part of an adaptive array.

45. The system of claim 44, wherein said plurality of sector input signal path control means are operable for amplitude adjusting signal components of ones of said plurality of sector input signals, wherein amplitude adjustment of said signal components of ones of said plurality of sector input signals is operable to adjust a longitudinal size of at least a portion of a variable size sector of said plurality of variable size sectors.

46. The system of claim 44, wherein said plurality of sector output signal path control means are operable for amplitude adjusting signal components of ones of said plurality of sector output signals, wherein amplitude adjustment of said signal components of ones of said plurality of sector output signals is operable to adjust a longitudinal size of at least a portion of a variable size sector of said plurality of variable size sectors.

47. The system of claim 44, wherein said plurality of sector input signal path control means are operable for phase adjusting signal components of ones of said plurality of sector input signals, wherein phase adjustment of said signal components of ones of said plurality of sector input signals is operable to adjust an azimuthal width of at least a portion of a variable size sector of said plurality of variable size sectors.

48. The system of claim 44, wherein said plurality of sector output signal path control means are operable for phase adjusting signal components of ones of said plurality of sector output signals, wherein phase adjustment of said signal components of ones of said plurality of sector output signals is operable to adjust an azimuthal size of at least a portion of a variable size sector of said plurality of variable size sectors.

49. The system of claim 37, wherein said control means substantially automatically controls said input signal path control means and said output signal path control means to provide dynamic size adjustment of ones of said plurality of variable size sectors.

50. The system of claim 49, wherein said control means operates to substantially automatically control said input signal path control means and said output signal path control means as a function of communication information determined by said system.

51. The system of claim 49, wherein said control means operates to substantially automatically control said input signal path control means and said output signal path control means as a function of a signal provided by a centralized controller operating to control a plurality of cooperating communication systems.

52. A method for providing a variable size sector in a radiation pattern comprising of a plurality of sectors, using a transceiver apparatus having a plurality of ports, wherein ones of said plurality of ports are each associated with a particular sector of said plurality of sectors, said method comprising the steps of:

providing an adaptive array to automatically adjust at least one of a phase and an amplitude of signal components of select ones of a plurality of sector signals, wherein at least one of said ones of said plurality of sector signals is associated with said variable size sector; and

forming said variable size sector in said radiation pattern, wherein said at least one of said ones of said plurality of sector signals is associated with at least one of said plurality of ports of said transceiver apparatus, wherein said at least one port of said transceiver apparatus is associated with said variable size sector.

53. The method of claim 52, further comprising the step of:

determining at least one of forward and reverse traffic loads across said plurality of sectors.

54. The method of claim 53, wherein said automatic adjustment of said at least one of a phase and an amplitude of signal components of select ones of said plurality of sector signals at least one of which is associated with said variable size sector is based on said determined traffic loads across said plurality of sectors.

55. The method of claim 52, wherein an azimuthal width of said variable size sector is determined in part by said phase adjustment of signal components of select ones of said plurality of sector signals.

56. The method of claim 55, wherein said variable size sector azimuthally overlaps another sector of said plurality of sectors, said overlap being a function of the relative phase adjustment of signal components of select ones of said plurality of sector signals at least one of which is associated with said variable size sector and at least another one of which is associated with said another sector of said plurality of sectors.

57. The method of claim 52, wherein a length of said variable size sector is determined in part by said amplitude adjustment of signal components of select ones of said plurality of sector signals.

58. The method of claim 57, wherein said variable size sector longitudinally overlaps another sector of another radiation pattern, said overlap being a function of the relative amplitude adjustment of signal components of select ones of said plurality of sector signals at least one of which is associated with said variable size sector and relative amplitude adjustment of signal components of select ones of another plurality of signals at least one of which is associated with another sector of another plurality of sectors of said another radiation pattern.

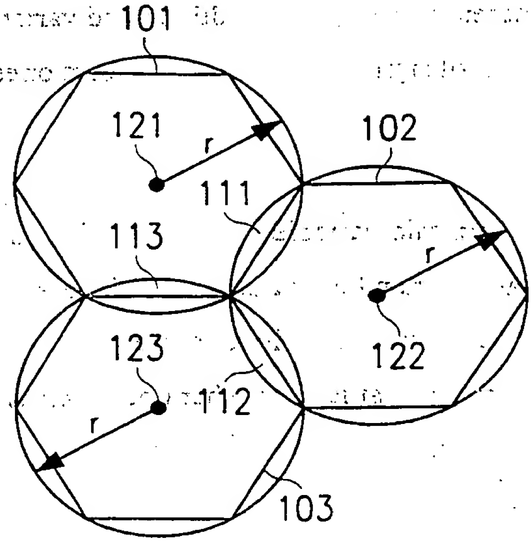


FIG. 1A

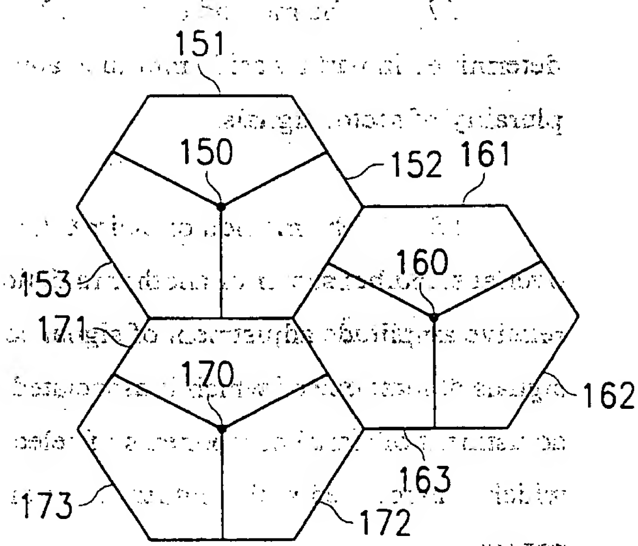


FIG. 1B

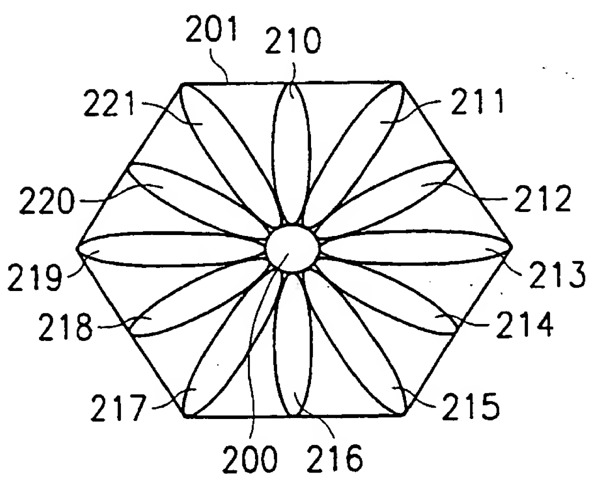


FIG. 2

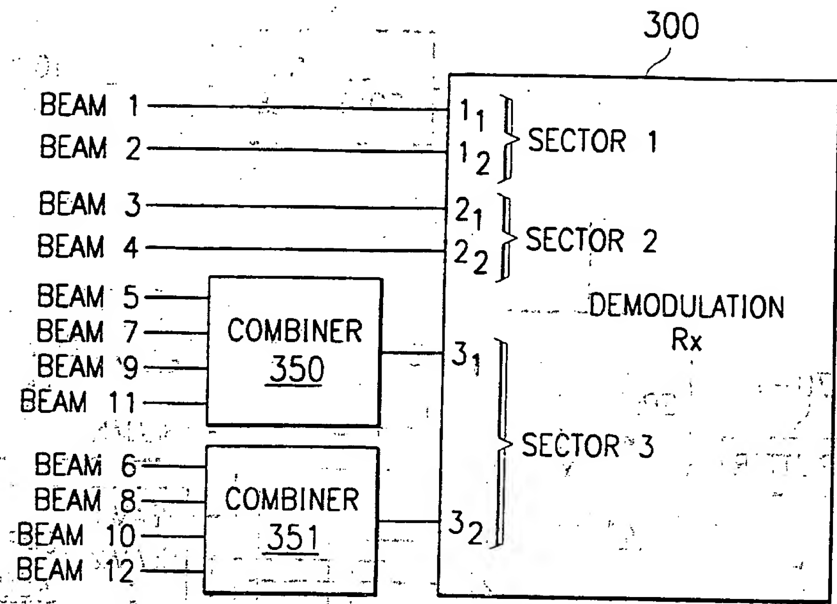

300
BEAM 1
BEAM 2
BEAM 3
BEAM 4
BEAM 5
BEAM 7
BEAM 9
BEAM 11
BEAM 6
BEAM 8
BEAM 10
BEAM 12
COMBINER 350
COMBINER 351
1_1
1_2
SECTOR 1
2_1
2_2
SECTOR 2
DEMODULATION Rx
3_1
3_2
SECTOR 3

FIG. 3A

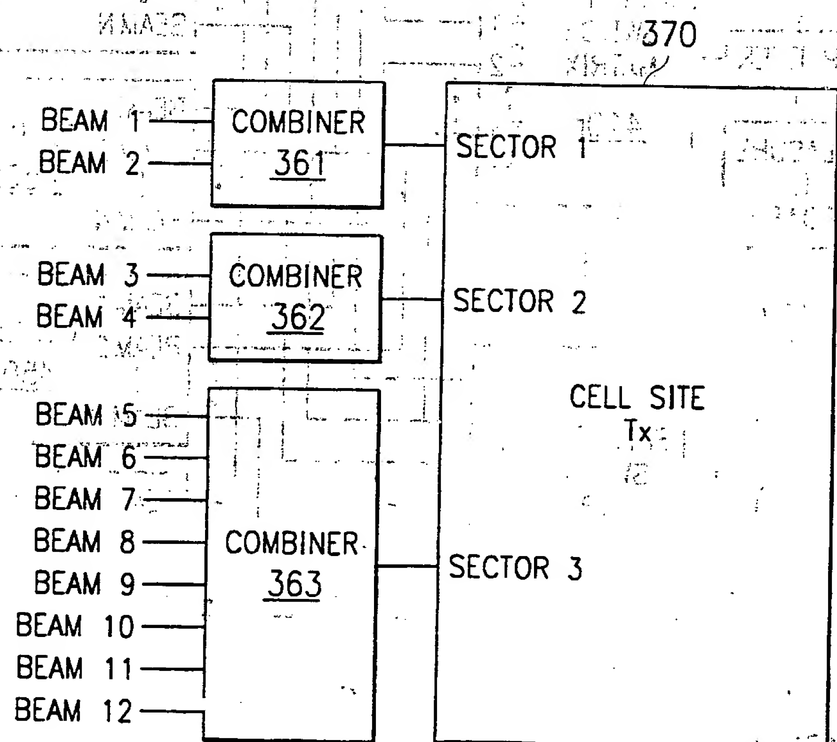

370
BEAM 1
BEAM 2
COMBINER 361
BEAM 3
BEAM 4
COMBINER 362
BEAM 5
BEAM 6
BEAM 7
BEAM 8
BEAM 9
BEAM 10
BEAM 11
BEAM 12
COMBINER 363
SECTOR 1
SECTOR 2
CELL SITE Tx
SECTOR 3

FIG. 3B

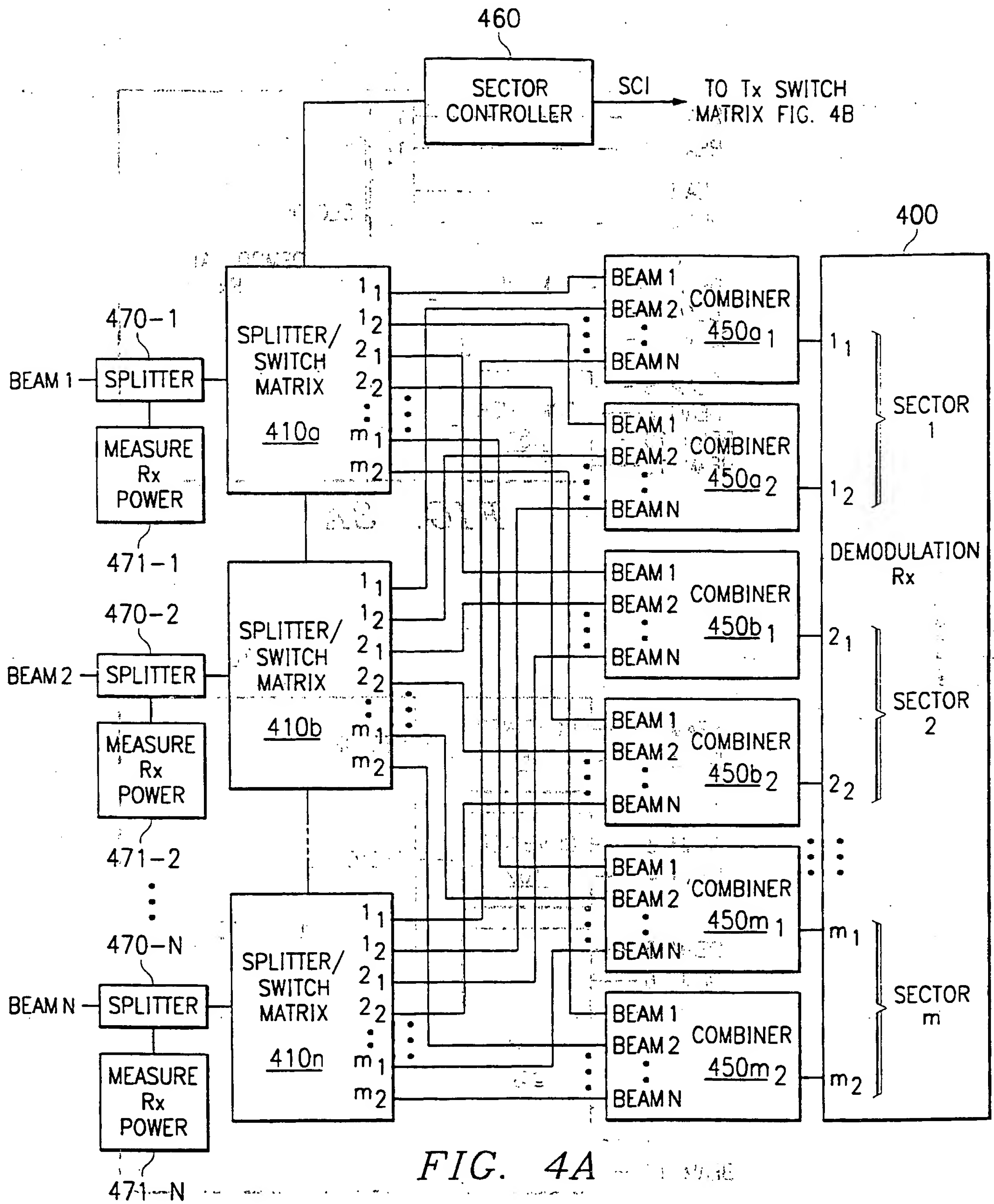

460
SECTOR CONTROLLER
SCI
TO Tx SWITCH MATRIX FIG. 4B
400
470−1
BEAM 1
SPLITTER
MEASURE Rx POWER
471−1
SPLITTER/ SWITCH MATRIX
410a
SPLITTER/ SWITCH MATRIX
410b
SPLITTER/ SWITCH MATRIX
410n
470−2
BEAM 2
471−2
470−N
BEAM N
471−N
BEAM 1
BEAM 2
BEAM N
COMBINER
450a 1
450a 2
450b 1
450b 2
450m 1
450m 2
SECTOR 1
SECTOR 2
SECTOR m
DEMODULATION Rx

FIG. 4A

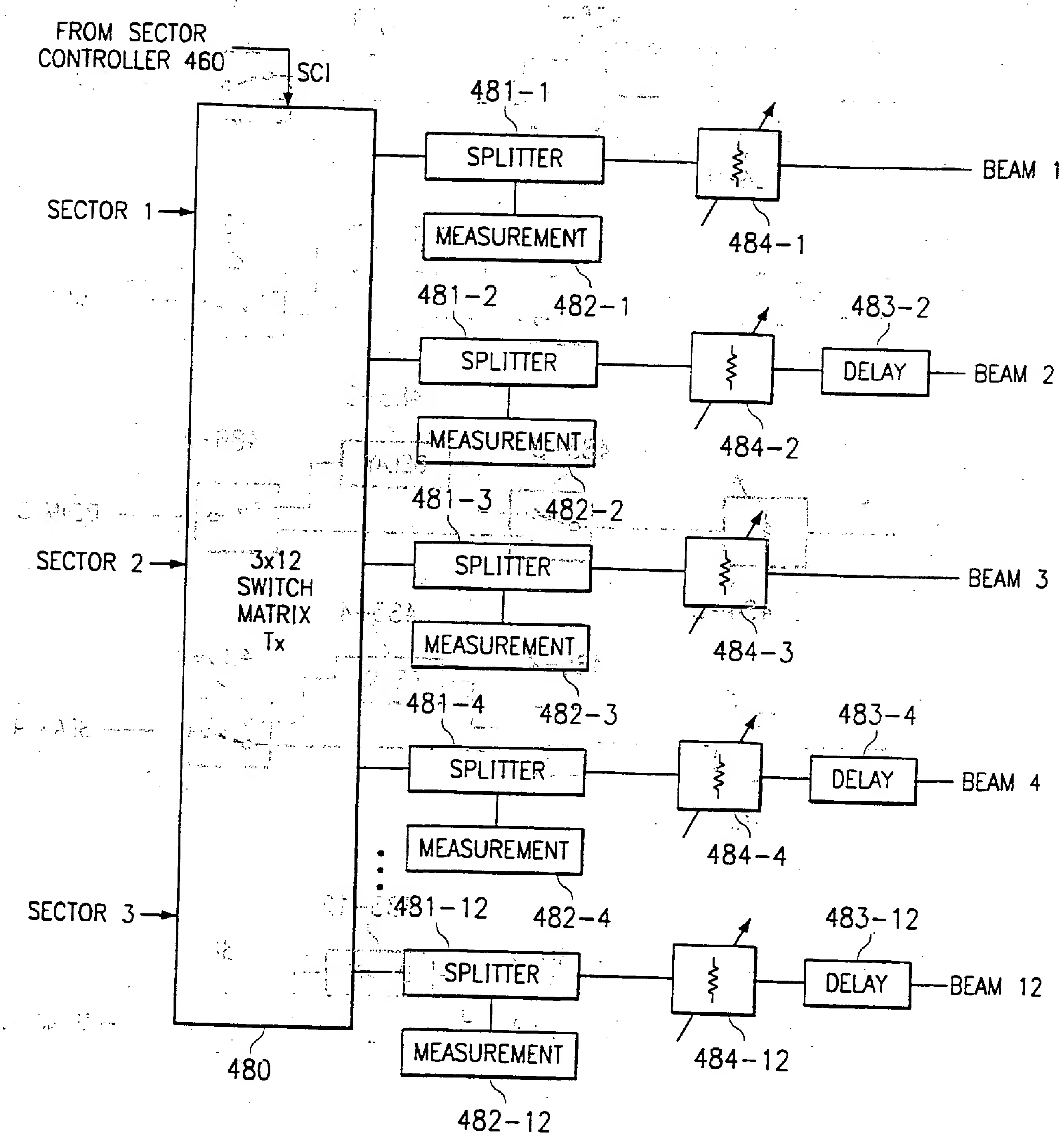
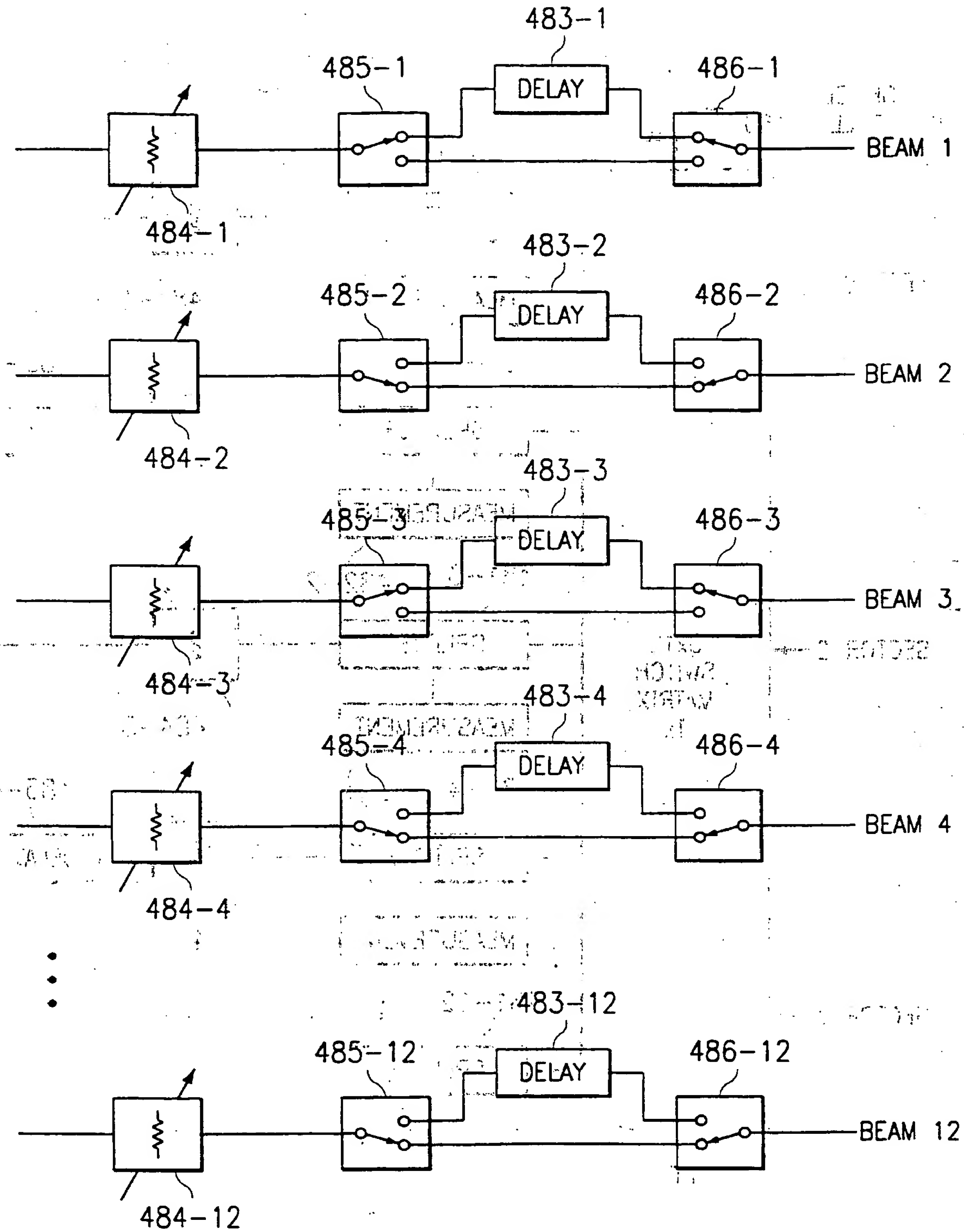

FROM SECTOR
CONTROLLER 460
SCI
SECTOR 1
SECTOR 2
SECTOR 3
3x12
SWITCH
MATRIX
Tx
480
481-1
SPLITTER
MEASUREMENT
482-1
484-1
BEAM 1
481-2
482-2
483-2
484-2
DELAY
BEAM 2
481-3
482-3
484-3
BEAM 3
481-4
482-4
483-4
484-4
BEAM 4
481-12
482-12
483-12
484-12
BEAM 12

FIG. 4B



483-1
485-1
DELAY
486-1
BEAM 1
484-1
483-2
485-2
DELAY
486-2
BEAM 2
484-2
483-3
485-3
DELAY
486-3
BEAM 3
484-3
483-4
485-4
DELAY
486-4
BEAM 4
484-4
483-12
485-12
DELAY
486-12
BEAM 12
484-12

FIG. 4C

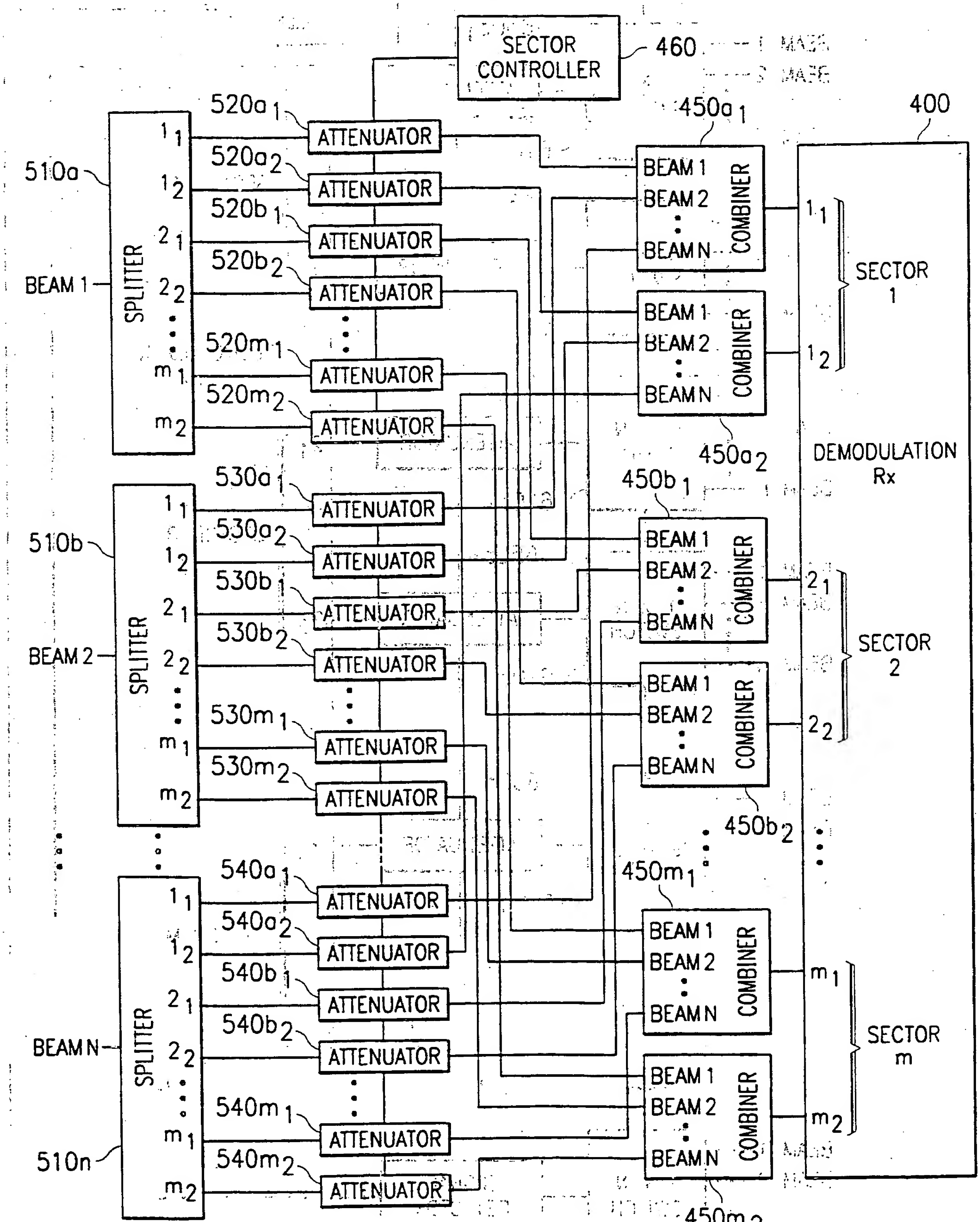
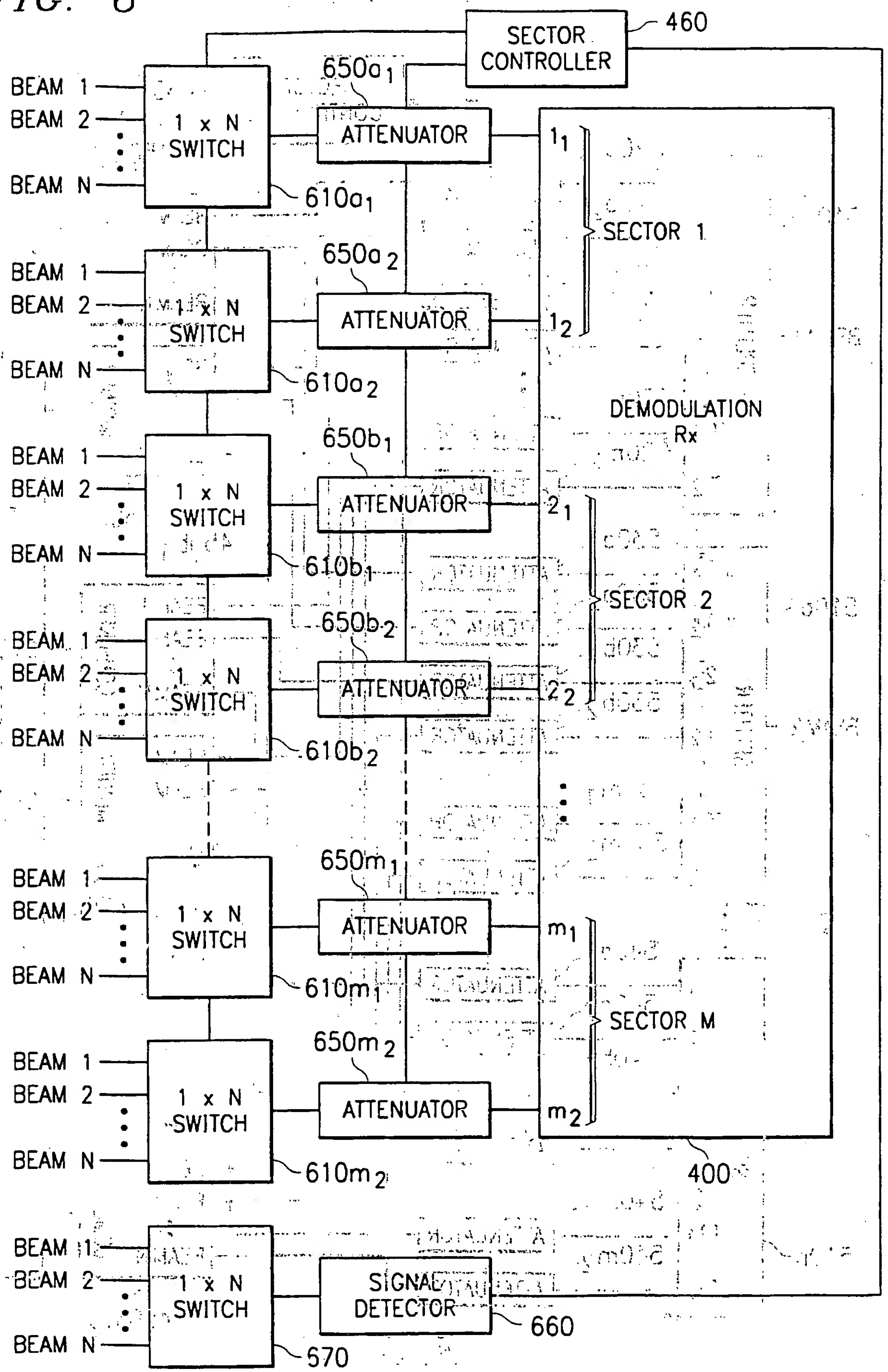
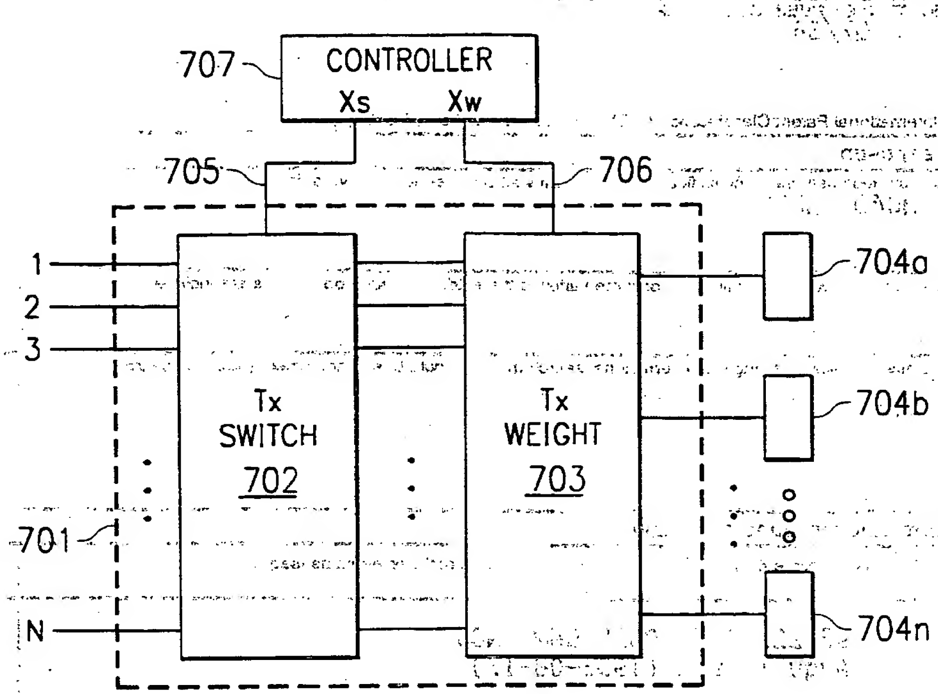

SECTOR CONTROLLER
460
400
DEMODULATION Rx
SPLITTER
ATTENUATOR
COMBINER
BEAM 1
BEAM 2
BEAM N
510a
510b
510n
520a1
520a2
520b1
520b2
520m1
520m2
530a1
530a2
530b1
530b2
530m1
530m2
540a1
540a2
540b1
540b2
540m1
540m2
450a1
450a2
450b1
450b2
450m1
450m2
SECTOR 1
SECTOR 2
SECTOR m

FIG. 5

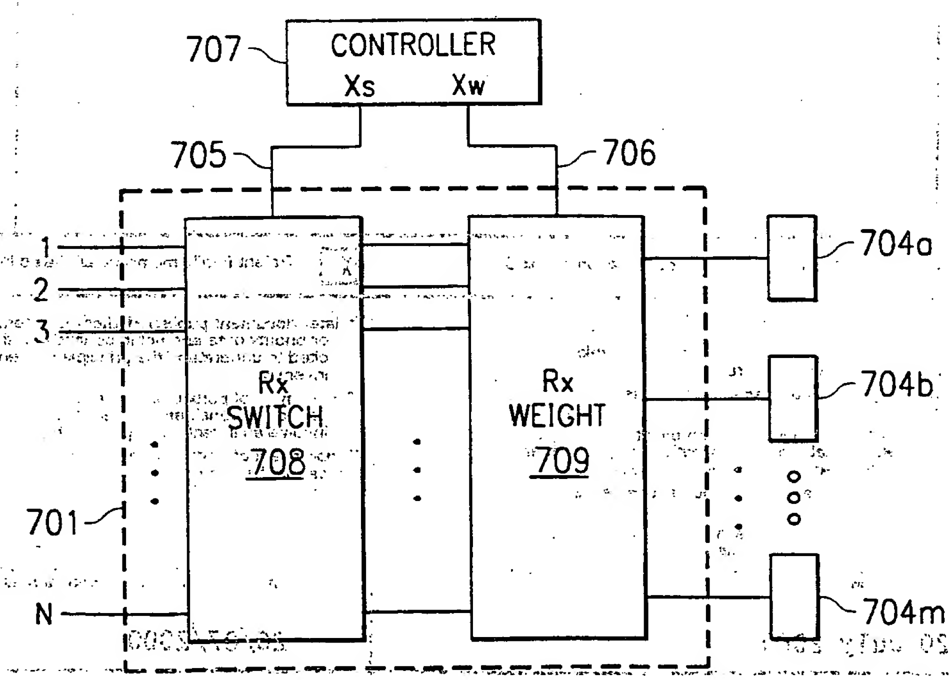
FIG. 6


SECTOR CONTROLLER
460
BEAM 1
BEAM 2
BEAM N
1 x N SWITCH
ATTENUATOR
650a1
610a1
650a2
610a2
650b1
610b1
650b2
610b2
650m1
610m1
650m2
610m2
1_1
1_2
SECTOR 1
DEMODULATION Rx
2_1
2_2
SECTOR 2
m_1
m_2
SECTOR M
400
SIGNAL DETECTOR
660
570



CONTROLLER
Xs
Xw
707
705
706
1
2
3
N
701
Tx
SWITCH
702
Tx
WEIGHT
703
704a
704b
704n

FIG. 7A



CONTROLLER
Xs
Xw
707
705
706
1
2
3
N
701
Rx
SWITCH
708
Rx
WEIGHT
709
704a
704b
704m

FIG. 7B

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 00/06889

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04Q7/36

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04Q H01Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 22210 A (QUALCOMM INC) 17 August 1995 (1995-08-17) page 4, line 29 -page 5, line 7 page 7, line 24 -page 9, line 25 page 10, line 18 - line 29 page 11, line 39 -page 13, line 13 page 15, line 9 - line 16 page 20, line 10 -page 22, line 33 --- -/--	1-6, 12-19, 23-41, 44-55

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
20 July 2000	26/07/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gerling, J.C.J.

1

International Application No
PCT/US 00/06889

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 889 494 A (REUDINK DOUGLAS O ET AL) 30 March 1999 (1999-03-30) cited in the application column 3, line 22 -column 5, line 12 column 8, line 32 - line 40 column 9, line 10 - line 26 column 10, line 57 -column 12, line 18 column 17, line 32 - line 48	1,7,8, 11, 16-19, 21,23, 25,33, 35,37, 39,49-51

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 00/06889

Patent document cited in search report		Publication date	Patent family member(s)			Publication date
WO 9522210	A	17-08-1995	AU	682939	B	23-10-1997
			AU	1876295	A	29-08-1995
			BR	9506683	A	16-09-1997
			CA	2183258	A	17-08-1995
			CN	1146832	A	02-04-1997
			EP	0775393	A	28-05-1997
			FI	963153	A	10-10-1996
			JP	10500807	T	20-01-1998
			ZA	9500797	A	20-06-1996
US 5889494	A	30-03-1999	NONE			